NEW SERIES XI.

DOVE MARINE LABORATORY,

CULLERCOATS, NORTHUMBERLAND.

REPORT

For the year ending June 30th, 1922.

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AND

DIRECTOR OF THE DOVE MARINE LABORATORY.

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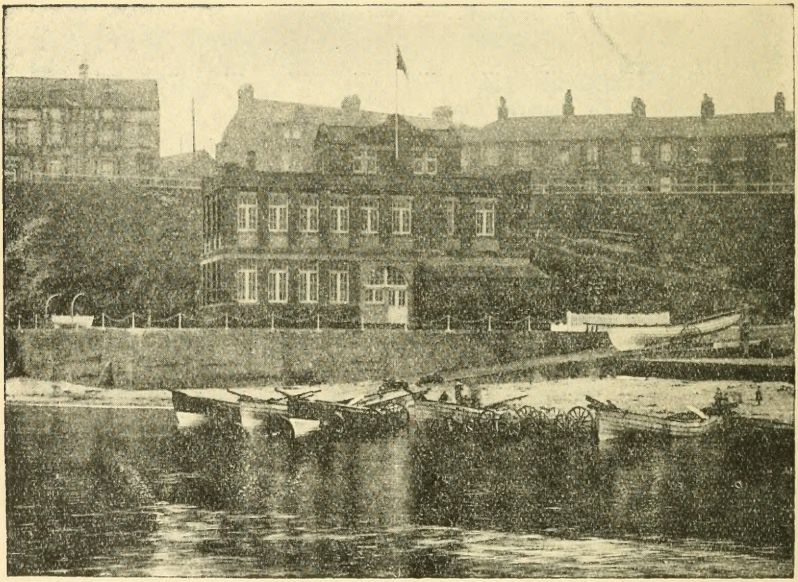

Dove Marine Laboratory, Cullercoats.

SUMMARY AND GENERAL REPORT.

The work of the Laboratory during the past year has been directed mainly to plankton, but the results are far from being ready. The following report, as will be seen, refers to other investigations, which have progressed sufficiently to warrant publication.

An opportunity was taken during a voyage of the "Evadne" to test an otter trawl, and although the results are not quite comparable with those obtained with the use of the beam trawl, they are interesting enough to record.

The herring investigations during the past year were extended, and samples were examined by Mr. Storrow and Mrs. Cowan from the west of Ireland, the Irish Sea and the Firth of Clyde, as well as from the North Sea and the waters about the north-west of Ireland and the north of Scotland. Altogether, 25 samples, comprising some 4,700 herrings, have been examined.

The age composition of the shoals is much the same as in the previous year, if allowance be made for the fish being a year older. Further evidence has been obtained which supports the idea that abnormal numbers of young fish joined the spring spawning shoals of 1921. The Firth of Clyde shoals differ from other shoals in having their greatest numbers belonging to the 1917 year-class, and an abundance of the same year-class was indicated in the waters to the west of the Shetlands by a sample obtained in June of this year.

The failure of the fishery is held to be due chiefly to a shortage of fish with three winter rings, and this shortage in summer shoals was intensified by the young fish joining spring spawning shoals in 1921. The Yarmouth grounds received

additions of older fish throughout the season, and with these additions the quality—never good—improved.

A large quantity of data has been accumulated relating to the growth of the herring, but is not here published unless it refers to shoals not previously sampled.

Further sampling of Yarmouth shoals points to recovering spents remaining in Yarmouth waters until June. Whilst the Firth of Forth shoals appear to have received additions from the 1918 year-class, there is no datum which points to their being recruits from the 1917 year-class. The Firth of Clyde herrings differ in growth from those of the north-west of Ireland and to a less extent, and only in later years from the fish of the Irish Sea.

Attention is drawn to the formation of a new spawning ground for spring herrings in our district. For two years now shoals have spawned between Holy Island and Berwick in 12 to 15 fathoms.

Mrs. Cowan reports on the size of the herrings examined. From the differences found between the samples from the Shetlands in July and August it is evident that many shoals frequent these northern waters, and further work is necessary before a full knowledge of their number can be obtained. To a less extent the same applies to the shoals of the north-west of Ireland and those of the north of Scotland, between the Sutherlandshire coast and the Butt of Lewis. The Irish Sea samples show these herrings to be of a much smaller size than those examined from the north-west coast of Ireland.

Mr. Storrow in a paper entitled "Notes suggestive of further work in Herring Investigations" has brought together a number of facts and coincidences which are worthy of consideration.

Some of the results of the work in biochemistry are communicated in three short papers by Miss Meek. In that relating to the salinity of the inshore waters, attention is drawn to the influence of the ebb tide in bringing water of low salinity

derived from the Tyne into the neighbourhood of Cullercoats. The pollution of the Tyne has occupied a good part of the time of the biochemist. An experimental sub-committee for the watershed of the River Tyne has been formed with a view to making enquiries and reporting to the Ministry's Standing Committee on Rivers Pollution. A full general report is being prepared, but a general account of the nature of the work and of the results is given. Miss Meek also contributes a short note on the influence of temperature on the growth of Zoarces.

Mr. Flattely describes a variety of *Pleurocrypta galatheae*, and I have mentioned the discovery of a new species, *Glossobalanus marginatus*, off the Longstone, an account of which will be published in the "Quarterly Journal of Microscopical Science."

Faunistic Notes are appended by Mr. Storrow.

In conclusion, I would like to express my thanks to all who send their publications to the Laboratory's library, and to those who have responded so generously to the librarian's request for exchanges.

ALEXANDER MEEK.

October 30th, 1922.

TRAWLING EXPERIMENTS.

By A. MEEK.

The experiments were made to test a small otter trawl, and the results are not therefore comparable with those of previous experiments.

The mesh of the net is larger than that of our beam trawl, and the larger mesh is effective in preventing the catch of the smaller flat fish. It was interesting to see, however, that the numbers captured at the stations examined bore the same proportion as our experiments in former years have shown to be so characteristic of the coastal waters. The catches are, for this reason added to our records. The tables show that if the younger fish are poorly represented, the older fish were similar in numbers to those of previous years.

The experimental hauls were made in September last year. At Skate Roads, as we have had occasion to note before, there was a quantity of weed, and the plaice especially indicated its presence by their dark colour. In former years also we have recorded the presence in the bays at this season of September of large numbers of edible crabs in the soft condition. Such were present, and were particularly abundant at Skate Roads and at Alnmouth. The numbers captured in an hour were 25 at Skate Roads and 30 at Alnmouth. Although it is not an unusual occurrence, it is worth stating to indicate to what a large extent crabs cast in the autumn, and the dispersion which takes place after the event.

20th September, 1921. SKATE ROADS. Began 1·48 p.m., ended 2·48 p.m. Time, 1 hour.

CENTIMETRES.

Name of Fish.	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	43	44	45	Total.
Plaice ...	—	—	—	1	—	—	—	—	3	—	3	4	2	3	4	9	4	5	3	2	1	3	3	2	—	—	—	—	—	—	52
Dab ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Flounder	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	1	—	3
Skate ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Angler ...	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	4
																														Grand Total	62

21st September, 1921. ALNMOUTH BAY. Began 1·45 p.m., ended 2·45 p.m. Time, 1 hour.

CENTIMETRES.

Name of Fish.	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	42	43	44	48	Total.
Plaice ...	—	1	1	—	1	2	2	4	3	—	2	2	5	3	—	1	1	2	—	—	1	1	—	—	—	—	—	—	—	—	32
Dab ...	—	—	—	—	2	5	5	3	4	3	—	1	2	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	27
Sole ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Whiting ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Haddock	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
																														Grand Total	63

21st September, 1921. **DRURIDGE BAY.** Began 3·40 p.m., ended 4·40 p.m. Time, 1 hour.

CENTIMETRES.

Name of Fish.	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	48	Total.
Plaice† ...	1	—	—	2	—	—	—	—	2	—	2	—	—	1	2	1	3	2	1	4	4	2	—	2	1	—	—	—	1	1	34
Dab ...	—	—	—	—	—	—	2	3	3	2	3	2	2	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	19
Flounder	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Gurnard ...	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Haddock	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	4
Whiting ...	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Skate* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1

† One at 53 cm. and one at 70 cm. * One at 61 cm.

Grand Total 63

HERRING INVESTIGATIONS.

I.—HERRING SHOALS.

By B. STORROW.

The object of the investigations during the past year was to obtain further evidence as to the age composition and development of the herring shoals already sampled, to obtain information with regard to the May, June and early July shoals which are known to occur under favourable circumstances off the north-west of Ireland, the Atlantic side of the Hebrides, to the west of the Orkneys and Shetlands, and also in Yarmouth waters, and to extend our knowledge of Irish herrings by the examination of samples from the Irish Sea.

As in 1920, frequent examinations of the samples displayed for sale at the herring ring at North Shields fish quay were relied upon to give a knowledge—more extensive than could have been obtained by the examination of samples at the Laboratory—of the summer shoals of young developing herring. Autumn spawning shoals have been examined from the grounds off Lerwick, Wick and Peterhead, and the East Anglian fishery yielded samples from Yarmouth in June, October, November and December. The spring spawning shoals off the Shetlands, the north coast of Sutherlandshire and the Firth of Forth were sampled in the early months of this year, and on account of the improvement of the Firth of Clyde fishery, samples were obtained from Girvan in February and early March. Samples from the Irish Sea were examined from the end of June to the beginning of September, and the spring spawning shoals as fished from Buncrana were dealt with in January and March. From Galway a sample was obtained in December.

The unsettled state of Ireland made it impossible to forward any samples of the early summer fishery, May, June and early July, from the north-west coast, but Mr. G. P. Farran measured

and scaled a sample at Downings in June, and forwarded the scales to me for age determination. On account of the nature of the fishery, the officers of the Fishery Board for Scotland were unable to obtain any samples from similar shoals from Scottish waters, and Mr. Brown, of Lerwick, for the same reason, was not able to send a sample from the west of the Shetlands in 1921. As herrings were sighted in June of this year, a trial was made in the waters to the west of the Shetlands, and owing to the keen interest which Mr. Brown has in these investigations it is possible to give some data regarding the herrings from these grounds.

As in previous years the sampling of the shoals has been made possible by the help of friends in various fishing ports, and the opportunity is here taken of expressing my thanks to those who have helped, not only by forwarding samples but by supplying a great deal of information about the fisheries from the various ports. Mr. Beazor, of Yarmouth, has given samples for examination; the Fishery Board for Scotland have, through their officers, forwarded samples and given information whenever requested to do so; to the Department of Agriculture and Technical Instruction for Ireland, Fisheries Branch, I am indebted for samples of Irish herrings; the officials of the Ministry of Agriculture and Fisheries at North Shields have shown their usual kindness and consideration.

The amount of help received from Mrs. Cowan has been considerable, and it is difficult to express fully my indebtedness; without this help the number of samples could not have been examined.

A list of the samples is given below. For each fish the length, sex, development of gonads and the age have been recorded, and the yearly growth, obtained by expressing the length of the fish in terms of the scale, has been calculated.

Port.	Date.	Origin.	Catch.	Number Examined.
Lerwick	2nd July, 1921 ...	25 miles S. from Bressay	Few crans*...	198
	24th August, 1921 ...	8 miles E.S.E. from Bressay	(?)	195
	4th March, 1922 ...	8 miles N.N.E. from Lamba Ness (E. from Muckle Flugga) ...	202 crans ...	168
	7th June, 1922 ...	15 miles N.W. from Ramna Stacks	30 crans ...	194
Wick	23rd August, 1921 ...	3 miles from Clyth Ness	80 crans ...	209
	8th February, 1922	7 to 8 miles W. by N. from Whiten Head	70 crans ...	162
	17th February 1922	10 miles from Cape Wrath	80 crans ...	207
	18th March, 1922 ...	14 to 15 miles N.W. by N. from Butt of Lewis	130 crans ...	176
Peterhead ...	27th August, 1921 ...	5 miles E. from Kinnaird Head	80 crans ...	202
Firth of Forth ...	9th February, 1922	Between Burntisland and Allca	1 cran ...	298
Great Yarmouth	7th June, 1921 ...	11 miles E.S.E. from Yarmouth	(?)	128
	20th October, 1921	11 miles N.N.E. from North Haisborough Light	66 crans ...	134
	27th October, 1921	12¼ miles E. by N. from Yarmouth	52 crans ...	186
	29th November, 1921	6 miles E. from Smith's Knoll Light	36 crans ...	142
	15th December, 1921	E.N.E. from Smith's Knoll Gas Buoy	27 crans ...	135
Girvan	9th February, 1922	Maidens Bay (ca. 5 miles north from Girvan)	15 crans ...	244
	2nd March, 1922 ...	Ballantrae Bank	15 crans ...	247
Irish Samples				
Ardglass	28th June, 1921 ...	13 miles S.E. from Ardglass	9 crans ...	210
	6th August, 1921 ...	25 miles S.E. by S. from Ardglass	12 crans ...	208
Kilkeel	22nd October, 1921....	1 mile S. from Kilkeel Harbour	12 crans ...	219
Howth	9th September, 1921	18 miles E.N.E. from Howth Harbour	3½ crans ...	192
Galway	13th December, 1921	Off Mutton Island Lighthouse, Galway Bay...	25 hundreds	208
Downings ...	8th June, 1921 ...	10 to 18 miles from Sheephaven	†	130
Buncrana ...	24th January, 1922...	8 miles N. from mouth of Lough Swilly	18 crans ...	186
	4th March, 1922 ...	25 miles from Lough Swilly	19¼ crans ...	194
		TOTAL	—	4772

* Nets destroyed by a whale.

† From catches of two steam drifters each with one-quarter cran.

Age and Maturity, Tables I. and II.—In determining age the last winter ring was taken as being inside the edge of the scale for all samples of 1921, and after 31st December the edge of the scale and last winter were taken as coinciding until new growth appeared.

The season commenced at North Shields as usual at the beginning of May with catches consisting chiefly of recovering spents from spring spawning shoals. The catches differed little from those generally made at this time, but were lower than in previous years, averaging for the first two weeks of the months between four and five crans per vessel. As the month advanced the catches became lower, and a gradual decrease continued until the second week in June when vessels averaged less than a cran per voyage. The samples at the herring ring showed quite clearly that the usual movement to the grounds off the Northumberland coast of young immature herrings, the beginning of the summer feeding shoals of developing herrings, had not taken place in the latter part of May. Small numbers of summer fish were seen, but these were not in sufficient quantities to influence the size of the catches, and were not greater than have been observed in some years, e.g., 1914, in catches made 100 miles from the port towards the end of April and in early May. On the 15th and 16th of June catches averaged about three crans, but dropped the following day, and it was not until 25th June that an average of little over six crans, the highest for the month, was obtained. Although the 25th of June showed a decided improvement in the fishery, the fish being more uniform in size and quality, and the samples for sale containing more fish with three winter rings than had been noticed previously, there were present comparatively large numbers of older fish which were recovering spents from spring spawning shoals. During the remainder of the month and early part of July, the catches varied from day to day from an average as low as a cran and a half to about seven crans. The number of fish with three winter rings became more numerous, and in the week ending 16th July they comprised the greater part of the samples. In this week the fishery was better than at any previous week of the season, and the 14th, with an average of only 12·4 crans per vessel, gave the highest average daily landing from the Northumberland shoals

for the season. The latter part of July was marked by an irregular fishery of small catches. In the first days of August the catches improved a little, and about 3 per cent. of the vessels landed 20 crans or over of good quality herrings, the majority of which were at stages IV. and V. of maturity. But these fish did not remain on the grounds, and the middle of the month was marked by small and irregular landings. A slight improvement took place towards the end of the month, but in the beginning of September the fishery was so poor that some of the vessels fishing from North Shields had begun to fish the grounds off Whitby and Scarborough.

The scarcity of herrings is well shown by a consideration of the daily average catches.

CRANS.

Week ending	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
16th July	4·9	7·2	8·1	12·4	4·6	3·0
23rd July	1·4	2·0	1·5	1·6	2·4	2·7
30th July	6·8	5·2	5·4	2·1	1·6	—
6th August	12·3	5·9	5·7	2·6	1·8	—
13th August	4·4	8·2	6·6	3·3	2·7	2·8
20th August	5·2	2 0	3·2	1·8	2·3	5·1

The figures above show the catches made during some of the best weeks of the fishery. They emphasise the scarcity of the herrings, and indicate the presence of small shoals which were unable to yield even moderate supplies for more than one or two days in each week. For the weeks ending 30th July and 6th August it would appear that after the first night's fishing the bulk of the herrings on the grounds had been caught or the others been scattered so much that a fleet of about 100 vessels was unable to find them in any numbers.

No catch of spawning herrings from local grounds was seen during the season, but some were landed in the beginning of September from the grounds off Whitby. The evidence of spawning from "spawny" haddocks was small, as owing to the price ruling at the time there was no great incentive for trawler fishermen to search for them. Some "spawny" haddocks were caught about 7 miles north-east of the Longstone towards the end of August, and on 1st October landings were made from 50 miles north-east of the Tyne.

The samples from Lerwick, Wick and Peterhead in 1921 show, if allowance be made for the fish being a year older, that

the age composition of the older fish was much the same as in the two previous years the shoals have been sampled. Herrings with seven and eight winter rings were fairly abundant, those with six winter rings were poor in numbers, and the fish with five winter rings, which gave the fairly good summer fishing of 1919, formed an important part of the catches. The Wick sample of 23rd August came from a spawning shoal, but contained a small number of young fish at stages II. to IV. It illustrates the importance of young fish with three winter rings and the extent to which they may influence the catches made even from spawning shoals. The sample from Lerwick, 2nd July, consisted for the most part of fish at stages II. and III., and can be considered as coming from a shoal which had recovered from a spring spawning.

Owing to the interest which Mr. Beazor takes in these investigations, it is possible to give some interesting data relating to the Yarmouth fishery. Mr. Beazor forwards samples, without charge, when he considers an examination may yield information which will lead to further knowledge.

The first sample came from the midsummer fishery on 7th June. This fishery was very poor, and the catches made from it were to some extent determined by the shortage of coal. But even when the vessels reached the fishing grounds the herrings were not caught in sufficient quantities to indicate that large shoals were present. It is doubtful, therefore, if the sample can be taken as giving a true representation of this fishery in a good season. It is interesting when compared with the sample caught 9th March * of the same year. The June sample contained more fish with four and five winter rings, and fewer fish with seven and eight winter rings. The March sample consisted of spents and recovering spents, and the fish of the June sample were further recovered, and at stage II. with more fat in the body cavity. Recovering spents from spring spawners were caught in Yarmouth waters in March, and as late as early June. The age composition of these two samples and the development were as follows :—

WINTER RINGS (Percentages).

Date.	3	4	5	6	7	8	9	10
9th March	1	3	27	15	17	24	11	2
7th June	5	30	34	8	11	9	2	1

* Report, New Series X., pp. 90 and 91.

MATURITY.

Date.	I.	II.	III.	IV.	V.	VI.	VII.	VII.-II.	Total.
9th March ...	2	1	—	—	—	—	126	42	171
7th June ...	1	127	—	—	—	—	—	—	128

An inspection of some herrings when at Yarmouth, 1st July of this year, proved the fish to be similar to those of the June sample of 1921.

The autumn fishery at Yarmouth was late, and it was not until the third week of October that herrings were caught in any great quantity. In this week a great wave of fish invaded the East Anglian grounds, and are represented by the sample of 20th October. The sample was peculiar in that it contained over 50 per cent. of fish with three winter rings, and came from a spawning shoal, 123 out of 134 herrings being at stage VI.; only five fish were at stage IV. or lower. In trade descriptions the herrings caught at this time were said to be poor in quality and small fish. In the following week another sample was received from fish caught 27th October, and Mr. Beazor described them as being the best landed up to that time, though far from the usual good quality. The sample showed a decrease in the number of young fish of three winter rings, and additions to the shoals of the older herrings, especially those with five winter rings. These were not spawning fish and the gonads were developed as far as stages III. and IV. only.

The poor quality of the herrings was a marked feature of the fishery, and towards the end of November this showed some improvement. The sample of 29th November shows how this improvement in quality coincided with the presence of more of the older fish on the grounds. Most of the herrings had five, six, seven and eight winter rings, and the gonads were at stages IV. and V. Fish at the same stages of development were contained in the sample of 15th December, practically the end of the season, but this sample showed the presence of greater numbers of herrings with seven and eight winter rings than obtained in the November sample.

The quality of the Yarmouth herrings improved with the movement of older herrings to the fishing grounds, but the herrings were never at any time of the season equal in quality to the fish expected from the fishery, and have been described as being of

a very watery nature and shrinking to simply skin and bone in the salt.

Spring spawning shoals about the Shetlands, north coast of Sutherlandshire (landed at Wick) and the Firth of Forth had much the same composition as in the previous year. The samples from the north coast of Sutherlandshire are particularly interesting as they show a comparatively high number of fish with four winter rings. An indication of this was shown in the sample of 26th February, 1921, from the same grounds but landed at Peterhead. At the time it was thought that the number of fish with three winter rings, equal to 17·5 per cent., might have been due to accidental sampling, as only one sample was examined from the fishery in 1921. It was to check the work of 1921 that three samples were examined this year. The third sample from Wick was caught off the Butt of Lewis. It consisted of spawning and spent fish, and its age composition was higher than the samples from the north coast of Sutherlandshire.

The Lerwick sample of 4th March contained more of the older fish, and it is difficult to say if 19 per cent. with four winter rings in 1922 and 10 per cent. with three winter rings in 1921 * can be considered as large numbers from shoals in Shetland waters. A consideration of the samples examined in 1920 † points to these percentages being high, but the number of shoals about the Shetlands needs more investigation before a definite statement can be made.

The high percentage of fish with four winter rings in the Firth of Forth sample of this year points to the same shoal returning to the same grounds as last season, when the herrings examined gave 65 per cent. of fish with three winter rings. In both seasons there were small numbers of larger and older fish which probably represent what was left of the shoal which was sampled from the Forth, 22nd January, 1920.‡ Fishermen have informed me that few of the larger herrings were caught during the past spring fishery, and Mr. Walker, of Newhaven, was unable to obtain a sample of any herrings different from those examined.

The samples from Girvan in February and March, and that from Lerwick from the west coast of the Shetlands, 7th June,

* Report, New Series X., page 90. † Report, New Series IX., page 43.
‡ Report, New Series IX., page 43.

are of interest. For some years the fisheries represented by these samples have been very poor. The fish from Maidens Bay, 9th February, were full fish, practically all of them sufficiently developed to spawn in spring. Those from Ballantrae Bank, 2nd March, were chiefly spawning fish. The sample from the west of the Shetlands, 7th June, consisted of spents. The age composition of these three samples differs altogether from that of any other sample examined in that by far the greater number of the herrings had five winter rings on the scales. Over 80 per cent. from the Clyde and 52 per cent. from the Shetland shoals were of this age.

The samples from Irish shoals came from the Irish Sea, the north-west coast and from Galway Bay. The Irish Sea sample from Ardglass, 28th June, consisted chiefly of young fish, the majority of them having three winter rings on the scales. In this respect and also as regards development it is very like samples from the North Sea at the same time of year, but it is marked by a high percentage, 34, of fish with two winter rings. The sample of 6th August from the same port consisted chiefly of herrings at stages III. and IV., and whilst fish with three winter rings formed the chief part of the sample there were fewer younger herrings and more of the older fish than in the June sample. Spawning shoals are represented by the samples from Kilkeel and Howth, 22nd October and 9th September respectively. The Kilkeel sample when forwarded for examination was described as consisting of "the usual inshore herrings caught at this time of the year." It contained 94 fish with two winter rings out of a total of 219, and of these 87 were spawning, 2 were spents and 5 were at stage IV. Such a high number of young spawning fish has not been found in any of the samples examined, and further data are required before the sample can be considered to represent the general age of first maturity for Irish Sea herrings. The Howth sample contained 30 fish with two winter rings in a total of 192, but of these 14 only were autumn spawners; the remainder, 16, of this year class were at stages I. to III.

From the spring spawning shoals of the north-west coast two samples were examined in January and March. In age they are like the samples of last year, and show the addition of young fish with four winter rings to the shoals. The January sample

consisted chiefly of full fish, and that of March of spawning fish and spents. In the January sample there were five herrings between stages II. and III., and since their age varied from six to eleven years they were probably recovered spents from autumn spawning shoals.

The June sample from Downings is the first from the north-west coast examined at this time of the year. Whilst fish of all ages were represented the predominant year-class was that with three winter rings. Mr. Farran classified the gonads as follows :—

Recovering spents	91
Spents, recovery not so great as above ...	13
Immature	13
Quarter mature = matties	13

Of the 26 immature and mattie herrings, 21 were fish with three winter rings, two had two winter rings, and three had four winter rings.

The sample from Galway Bay in December consisted of spent fish, and the chief year-class was that with three winter rings.

The summer fishery was a failure. At North Shields there was a scarcity of fish with three winter rings on the scales, and the number of recovering spents from spring spawning shoals formed an abnormally high portion of the catches until the middle of July.

As in 1920 many reasons were given for the failure of the summer fishery at North Shields and other ports. In 1920 the presence of "jelly fish" was supposed by fishermen to have much to do with the poor fishery. In 1921 sharks and dogfish were held to have destroyed the herrings. The reason for the failure was that the herrings were not present off the coast, and since it has been shown in previous reports that the summer fishery contains from 50 to 70 per cent. of fish with three winter rings on the scales, the scarcity of herrings was due to the year-class 1918—fish hatched in the autumn of 1917 and the spring of 1918—being very poor in numbers in the summer shoals.

Hydrographic conditions have been held to account for the failure of the fishery by causing the herrings to swim at depths not reached by the drift nets. The summer fishery was a general

and not a local failure, and from no waters have we records of shoals of mattie herrings being abundant, and some interesting information on this point has been forwarded to me by Mr. Moore, of Buncrana. When the fishermen of the north-west of Ireland are lying at the nets, it is their custom, as in other parts, to fish with lines for cod and coalfish. Mr. Moore examined these fish, and wrote me as follows:—"In past seasons these fish would have anything up to a score of herrings in their bellies from ones newly swallowed to others half digested. This season I did not see a dozen herrings in the bulk of 1,000 fish gutted by my men, and noticed that the fish in general, and especially the coalfish, were very badly matured, very small in size, and more the appearance of spent or slinky fish." Had the herrings been present, but at a greater depth than the nets, it is reasonable to suppose that the cod and coalfish would have captured them as in other years.

Good fisheries are determined chiefly by the presence of good year-classes, and these are hatched three years before they enter the shoals in sufficient numbers to influence the fishery. Hydrographic conditions may, and possibly do, influence migrations and the quality of the fish caught. The summer fishery last year was not poor, it was a failure, and from no waters have we records of large catches. Dutch luggers fishing in waters much further from the shore than do our vessels made very poor catches. The only area known which could be cited as giving a comparatively good fishery, whilst the neighbouring fisheries were poor, is the Firth of Clyde, and the age composition of these fish will be seen from Table I. to be altogether different from that of other shoals.

The age composition of the samples of spring spawning herring in February and March of 1921* showed that a number of young herrings at the end of their third year had joined the shoals. The joining of spawning shoals by fish so young is not unusual, but the numbers which did so appear to be greater than one would expect, especially for the waters of the Firth of Forth, Broad Bay and the north coast of Sutherlandshire. As the greater part of our summer feeding shoals of developing herring consists of fish in their fourth year the entering into spawning

* Report, New Series X., page 90.

shoals in the spring of the same year would doubtless tend to decrease the catches from summer feeding shoals. But the catches made from spring spawning shoals in 1921 and 1922 give no reason for concluding that these shoals have received enormous additions from a younger year-class, and they tend to emphasise the conclusion already expressed that the failure of the fishery was due chiefly to the year-class of 1918 being poor. Whilst this is considered the chief reason for the failure of the fishery, there is no doubt it was accentuated by the number of young fish joining the spring spawning shoals of 1921.

The season of 1921 was very much the same as, but worse than, the season of 1920. The catches from spring spawning shoals and their age composition, together with the catches from summer shoals, indicate that the year-classes which would make the summer fisheries of 1920 and 1921 can be considered of little value to the fishery. The poor fishery from other shoals, as those off Yarmouth in October and November was doubtless due in part to the poor year-classes of 1917 and 1918 not yielding sufficient immigrants into the shoals, but the age composition of the older herrings deserves consideration. Amongst the older fish the year-class of 1916, fish with five winter rings in 1921 and which gave the summer fishery in 1919, can be said to be a fairly good but not a rich year-class. The year-class of 1915 has been poorly represented in every sample of herrings examined. Fish with seven and eight winter rings in 1921, six and seven winter rings in 1920, five and six winter rings in 1919, and belonging to the year-classes 1913 and 1914 have always been present in the samples in higher numbers than the 1915 year-class. But these fish must naturally be decreasing in numbers and be unable of themselves to yield a productive fishery. Before there can be any considerable improvement in our herring fishery a good year-class is a necessity, and the first appearance of it will be shown by increased catches from summer feeding shoals.

The possibility of North Sea herrings entering the Baltic with increased activity of Atlantic waters is worthy of consideration, but no data are available in this connexion. Abnormally high catches from the Baltic and waters leading to it would have to be made to account for the shortage of herrings in our fisheries were the failure due to migrations only.

The quality of the fish throughout the season from a curing consideration was remarkably poor, the herrings shrunk so much that few or no "Yarmouth Reds" were cured last year. The question of quality is one deserving of further work. The term "quality" in the herring trade has various meanings. It may refer to size, development of gonads, which determine to a large extent the bulk or weight of the fish, or it may refer to shrinkage of fish after curing by salt. The latter is influenced probably by the hydrographic conditions and food supplies of the year of capture.

There was great difference between the herrings from the Clyde area and those from Yarmouth waters. Numbers of these fish were seen in the curing houses at North Shields, and there was considerable difference between them. In the early part of the Yarmouth fishery the Clyde herrings were older than the Yarmouth fish, most of the former having four winter rings, but this difference of age cannot be said to have marked the two fisheries later in the season when older fish came from Yarmouth. In appearance the Clyde herrings were better fed fish than those from Yarmouth; they were plumper and broader across the back, and when smoked gave a kipper thicker in the flesh. It was found to be possible, when in the curing houses, to pick out the barrels of herrings according to their origin, and also in many cases to identify the kippers on the racks when they came out of the smoking houses.

Growth.—Particulars relating to growth will be found in Table III. Whilst for all samples the growth has been calculated by expressing the positions of the winter rings of the scale in terms of the length of the fish, only the data relating to shoals not previously sampled are given. As in previous years the lengths are expressed to the nearest centimetre, 8·6 to 9·5 cm being counted as 9 cm.

The Yarmouth samples of 7th June and 20th October are of interest in that the June sample came from a shoal of recovered spents from a spring spawning, and the October sample came from a shoal of autumn spawners, the majority of which were young fish at the end of their fourth year. The herrings with three and four winter rings in the October sample show a much slower growth than fish of the same age in the June sample. This difference is thought to be too great to be accounted for by the

more rapidly grown herrings joining spawning shoals at an earlier age than those of slower growth, and is taken as indicating that the fish of these ages have spent their early years on different feeding grounds. The small number of older fish in the October sample makes it impossible to offer any definite statement with regard to them, but they approach the growth of the older fish in the June sample.

In the Report for last year, page 87, data were given which pointed to the full fish of November returning to Yarmouth waters as spents in the spring fishery of the following year. The fish with five winter rings in the June sample of 1921 have a growth very like that of the fish of the same age in the March sample. This, together with the maturity data, point to the herrings staying some considerable time in Yarmouth waters when recovering from spawning. The growth data are as follows :—

FIRST YEAR GROWTH.

NUMBER AT CENTIMETRES.

Sample.	Winter Rings.	6	7	8	9	10	11	12	13	14	15	Total.
17/11/20 ...	4	1	6	17	28	8	10	5	1	2	1	79
9/3/21	5	—	1	11	15	9	6	2	1	—	1	46
7/6/21	5	2	3	10	6	5	4	3	9	1	—	43

SECOND YEAR GROWTH

NUMBER AT CENTIMETRES.

Sample.	Winter Rings.	14	15	16	17	18	19	20	21	22	Total.
17/11/20	4	2	7	14	15	16	13	11	1	—	79
9/3/21	5	2	1	12	9	11	1	9	1	—	46
7/6/21	5	—	6	8	1	7	8	7	5	1	43

THIRD YEAR GROWTH.

NUMBER AT CENTIMETRES.

Sample	Winter Rings.	19	20	21	22	23	24	25	Total.
17/11/20	4	—	6	14	26	25	8	—	79
9/3/21	5	1	—	10	17	10	7	1	46
7/6/21	5	—	3	6	10	16	6	2	43

FOURTH YEAR GROWTH.

NUMBER AT CENTIMETRES

Sample.	Winter Rings.	22	23	24	25	26	27	28	Total.
17/11/21	4	1	8	27	32	10	1	—	79
9/3/21	5	1	4	17	19	5	—	—	46
7/6/21	5	—	2	14	20	6	—	1	43

FIFTH YEAR GROWTH.

NUMBER AT CENTIMETRES.

Sample.	Winter Rings.	24	25	26	27	28	29	Total.
9/3/21	5	1	16	18	11	—	—	46
7/6/21	5	—	4	26	12	—	1	43

The age composition and development of the Firth of Forth sample compared with that of 1921, when so many herrings at the end of their third year were found in the sample examined, makes a comparison of the growth data desirable, and for this purpose the growth of both the 1921 and 1922 sample will be found in Table III. For first year growth the majority of the three winter ringed herring of the 1921 sample fall under centimetres 9 to 12, and four winter ringed fish in the 1922 sample are found chiefly under centimetres 8 to 11. For second and third year growth the majority of the fish will be found to be as follows :—

	Sample.	Centimetres.
Second Year Growth ...	1921	18 to 21
	1922	17 to 20
Third Year Growth ...	1921	23 to 25
	1922	22 to 24

Data have been given* which show that variation in growth accompanies variation in maturity, and in last year's Report it was stated that the difference in growth between fish with three and four winter rings in the Firth of Forth samples was taken as supporting the hypothesis that herrings, previous to reaching maturity, shoal according to size. From the data given above it appears that of the 1918 year-class it was the herrings which had made a comparatively rapid growth which joined the spring spawning shoals of 1921, and that the fish which had not grown so rapidly did not join the spawning shoals until a year later.

The growth made by the herrings of five winter rings in the sample of 1922 is much the same as that for fish with four winter rings in the 1921 sample. It cannot be said that this year-class, 1917, has given any noticeable additions in 1922 to the spring spawning shoals of the Forth.

The Girvan samples are the first which have been examined from the Clyde fishery, which has been a failure for so many years.

* Report, New Series IX.,

The peculiar age composition of the samples, the chief year-class being that with five winter rings, 1917, makes them different from any of the other samples examined. Our knowledge of the shoals to the west of Scotland is very small, and for Scottish waters near the Clyde we have no data for the growth of the herring, at least none which can be compared with that calculated from the scales. The nearest shoals for which we have growth data are those about the north-west of Ireland, reported upon in the Report of last year, and those of the Irish Sea sampled in 1921. For the purpose of comparison the growth of five winter ringed herrings in the Girvan samples, that of fish of the same age from the north-west of Ireland in 1921 and 1922, together with the growth of four and five winter ringed fish in the samples from Ardglass and Howth in August and September are given here. The range given for the different year growths is that under which the majority of the fish will be found.

	Clyde.	N.W. Ireland.	Irish Sea.	
			5 w.r.	4 w.r.
1st year growth	8—13	10—14	7—14	9—14 cm.
2nd ,, ,, ...	16—21	19—24	16—21	16—21 cm.
3rd ,, ,, ...	21—25	24—28	21—25	21—25 cm.
4th ,, ,, ...	24—28	27—30	24—27	24—27 cm.
5th ,, , ...	25—29	29—31	25—28 cm.	

It is clear that the herrings of the north-west of Ireland are different in growth from those of the Clyde. The Irish Sea herrings, which were from autumn spawning shoals, have in the first three years (up to first maturity probably) a growth very like those of the Clyde, but in the fourth and fifth years the Clyde fish tend to be a little larger.

Amongst the younger herrings, fish with three and four winter rings, in the Girvan samples a few large fish occurred, and these were first noticed by the larger and more boldly marked scales when determining age. These herrings may have come from Atlantic waters, but their numbers were no greater than have been noticed in other shoals, and their presence can be accounted for by the scattering of shoals after spawning and the more remote fish joining other shoals.

The growth data of the Irish Sea samples for herrings with two, three and four winter rings show peculiarities worthy of notice. Fish with two winter rings were alike in the Ardglass sample of

June, and that from Kilkeel in October. Both these samples show a more rapid growth for fish of this age than the Howth sample of September, the growth data of which give no evidence of being influenced by the development of the fish. Sixteen out of the thirty fish with two winter rings in the Howth sample were immature fish in a spawning shoal, and the second year growth was as follows :—

	Centimetres.						
	16	17	18	19	20	21	Total.
Immature ...	2	2	4	3	4	1	16
Mature ...	1	3	3	4	2	1	14

There is agreement also between fish with three winter rings in the June sample from Ardglass and the Kilkeel sample for the size attained at the end of the third year, but it will be seen in Table III. that the second year growth of these fish differs, and that those in the Kilkeel sample were then smaller.

The fish with three winter rings in the Ardglass August sample were larger fish, and had a more rapid growth in all years than the fish of the same age from the same port in June or from Kilkeel in October. This difference between the herrings of June and August is very like what has been found in the North Sea, and points to waves of immigrants coming into the Ardglass fishery during the season.

Herrings with four winter rings in the Kilkeel sample had a small size and a slow growth when compared with fish of the same age in the Ardglass August sample and the sample from Howth. This difference in growth and the small number, eight, of fish with more than four winter rings in the Kilkeel sample point to the Kilkeel shoals developing and spawning on grounds which receive no additions from the spawning shoals of older herrings.

Attention has been drawn already to the growth of the older fish.

Growth data for the June sample from Downings and the December sample from Galway Bay will be found in Table III., as these are the first samples examined from these fisheries. For the same reason growth data are given for the Lerwick sample from 15 miles N.W. of Ramna Stacks, June, 1922. The Downings and Galway Bay samples both have a smaller growth than that

of the samples of spring spawning herrings from the north-west coast of Ireland. The June sample from the Shetlands which, consisted chiefly of spent fish, is remarkable in that few of the herrings show on the scales any signs of growth for the year of capture. The data with regard to this growth are summarised as follows :—

Winter Rings.	2	3	4	5	6	7 and +	Total.
Number examined ...	2	11	31	101	18	29	192
Growth begun in ...	2	11	16	12	1	—	42
Average 1922 growth	1·8	0·8	0·4	0·3	0·3 cm.		

When in Berwick in the summer of 1921 I was informed that large quantities of herring spawn had been found in crab pots by fishermen fishing from that port in the spring of the year. To ascertain the extent of the spawning ground a query was addressed to the Fishery Board for Scotland, and the Board's officer at Berwick reported that no evidence of a spawning had been found from St. Abb's Head to Berwick, but that towards the latter end of March herring spawn had been found from three to four miles east by south from Berwick. The spawning was unusual in position and quantity, but shoals of herrings off the Berwickshire coast during the past winter had been greater than had been the case in former years.

To obtain further evidence of this new spawning ground Mr. James Anderson, of Burnmouth, Mr. Cowe, of Berwick, and Mr. Douglas, of Beadnell, were requested to make observations in the spring of 1922, and, if possible, to send samples of the spawn to Cullercoats. Herring eggs were obtained and sent to Cullercoats by Mr. Anderson and Mr. Cowe, and they came from 12 to 15 fathoms, 2 to 3 miles north from Emmanuel Head, Holy Island, 27th February and 1st March. Mr. Douglas who was fishing on grounds south of the Farne Islands found no traces of a spawning. The eggs covered the crab pots and the backs of the crabs caught. They were attached to pieces of old rope, shells of living Buccinum, Flustra and seaweeds. Where the spawn was thickest no crabs were caught. Whiting and cod were caught gorged with herring eggs.

TABLE I.—AGE.

WINTER RINGS. (PERCENTAGES)

Port and Date.	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1921.														
Lerwick—														
2nd July ...	—	11	15	22	10	17	16	8	2	—	—	0·5	—	198
24th August ...	—	12	16	23	9	20	10	7	2	2	—	—	—	195
Wick—														
23rd August ...	6	55	19	9	2	5	2	1	1	—	—	—	—	209
Peterhead—														
27th August ...	0·5	18	15	23	8	15	9	6	3	1	—	0·5	—	202
Gt. Yarmouth—														
7th June ...	—	5	30	34	8	11	9	2	1	—	—	—	—	128
20th October ...	7	55	19	5	2	5	5	2	—	1	1	—	—	134
27th October ...	2	40	22	20	5	7	3	0·5	0·5	—	—	—	—	186
29th November	—	6	16	32	11	19	9	6	—	—	—	—	—	142
15th December	—	2	19	24	16	24	10	3	2	—	—	—	—	135
Ardglass—														
28th June ...	34	48	6	6	2	2	1	—	0·5	—	—	—	—	210
6th August ...	6	33	26	21	9	3	1	—	—	—	—	—	—	208
Kilkeel—														
22nd October	43	44	10	2	+	1	+	—	—	—	—	—	—	219
Howth—														
9th September	*16	6	19	35	9	10	3	—	0·5	0·5	—	—	—	192
Galway—														
13th December	*16	37	26	14	2	2	0·5	—	—	—	—	—	—	208
Downings—														
8th June ...	2	32	16	16	8	16	7	2	1	—	—	—	—	130
1922.														
Lerwick—														
4th March ...	—	1	19	11	16	11	30	10	1	—	—	1	—	168
7th June ...	1	6	16	52	9	5	5	4	2	—	+	—	—	194
Wick—														
8th February	—	1	40	19	15	4	12	7	1	1	—	—	—	162
17th February	—	1	53	17	12	5	10	3	+	—	—	—	—	207
18th March ...	—	—	27	14	16	10	24	8	2	—	—	—	—	176
Firth of Forth—														
9th February	1	4	69	9	4	2	4	4	2	1	+	—	—	208
Girvan—														
9th February	—	5	12	78	5	—	1	—	—	—	—	—	—	244
2nd March ...	—	1	7	87	5	+	—	—	—	—	—	—	—	247
Buncrana—														
24th January	—	2	20	23	25	8	16	5	2	1	—	—	—	186
4th March ...	—	11	30	21	16	6	12	3	1	—	+	—	—	194

* Two per cent. with one winter ring.

TABLE II.—MATURITY.

Port and Date	I.	II.	III.	IV.	V.	VI.	VII.	VII.-II.	Total
1921.									
Lerwick—									
2nd July	17	87	75	19	—	—	—	—	198
24th August ...	—	1	—	—	—	51	142	1	195
Wick—									
23rd August ...	1	2	4	22	4	165	10	1	209
Peterhead—									
27th August ...	—	—	—	—	—	21	181	—	202
Great Yarmouth									
7th June	1	127	—	—	—	—	—	—	128
20th October ...	—	—	2	3	2	123	4	—	134
27th October ...	—	1	94	82	5	3	1	—	186
29th November ...	—	—	7	78	48	—	—	9	142
15th December ...	—	2	4	80	43	—	—	6	135
Ardglass—									
28th June	85	71	42	12	—	—	—	—	210
6th August ...	2	25	133	48	—	—	—	—	208
Kilkeel—									
22nd October ...	—	—	—	11	—	203	5	—	219
Howth—									
9th September ...	7	3	10	3	1	168	—	—	192
Galway—									
13th December ...	11	1	1	—	10	—	185	—	208
Downings—									
8th June	*13	—	13	—	—	—	13	91	130
1922.									
Lerwick—									
4th March	1	—	—	—	6	133	28	—	168
7th June	6	1	—	—	—	10	160	17	194
Wick—									
8th February ...	—	1	5	50	70	36	—	—	162
17th February ...	—	—	—	1	12	183	11	—	207
18th March... ...	—	—	—	—	5	116	51	4	176
Firth of Forth—									
9th February ...	3	—	54	113	58	68	—	2	298
Girvan—									
9th February ...	3	—	21	139	71	10	—	—	244
2nd March	—	—	—	—	26	217	4	—	247
Buncrana—									
24th January ...	—	†5	1	27	151	—	—	2	186
4th March	—	—	—	—	31	104	59	—	194

* 13 immature, 13 spents, 91 recovering spents, 13 matties.
† Between stages II. and III.

TABLE III.—GROWTH.

YARMOUTH SAMPLES—FIRST YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	6	7	8	9	10	11	12	13	14	15	Total.
7/6/21 ...	3	—	—	—	—	—	—	1	4	1	1	7
20/10/21	3	—	—	7	13	15	16	12	7	3	—	73
7/6/21 ...	4	—	1	1	6	6	10	6	6	2	1	39
20/10/21	4	—	3	2	3	7	6	4	1	—	—	26
7/6/21 ...	5	2	3	10	6	5	4	3	9	1	—	43
20/10/21	5	1	—	3	—	1	1	—	—	—	—	6
7/6/21 ...	6	—	—	4	2	1	—	2	1	—	—	10
20/10/21	6 and +	2	5	6	2	5	—	—	—	—	—	20
7/6/21 ...	7 and +	1	5	6	5	2	5	2	1	2	—	29

SECOND YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	13	14	15	16	17	18	19	20	21	22	Total
7/6/21 ...	3	—	—	—	—	—	—	1	1	3	2	7
20/10/21	3	—	—	—	7	12	14	24	9	7	—	73
7/6/21 ...	4	—	—	—	2	2	8	7	14	5	1	39
20/10/21	4	1	—	2	4	6	3	6	4	—	—	26
7/6/21 ...	5	—	—	6	8	1	7	8	7	5	1	43
20/10/21	5	—	1	2	2	—	—	—	1	—	—	6
7/6/21 ...	6	—	—	1	2	2	2	1	1	1	—	10
20/10/21	6 and +	2	2	2	5	4	3	2	—	—	—	20
7/6/21 ...	7 and +	1	2	4	8	2	1	6	4	1	—	29

THIRD YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	18	19	20	21	22	23	24	25	26	Total.
7/6/21 ...	3	—	—	—	—	—	—	3	2	2	7
20/10/21 ...	3	—	—	—	5	31	25	9	3	—	73
7/6/21 ...	4	—	—	—	3	5	11	15	5	—	39
20/10/21 ...	4	—	—	2	5	8	8	3	—	—	26
7/6/21 ...	5	—	—	3	6	10	16	6	2	—	43
20/10/21 ...	5	—	—	1	2	1	1	1	—	—	6
7/6/21 ...	6	—	—	1	1	3	4	1	—	—	10
20/10/21 ...	6 and +	2	—	4	5	5	4	—	—	—	20
7/6/21 ...	7 and +	—	3	2	9	4	8	2	1	—	29

TABLE III. (Continued).

YARMOUTH SAMPLES.—FOURTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	21	22	23	24	25	26	27	28	Total.
7/6/21 ...	4	—	—	—	2	16	13	7	1	39
20/10/21	4	—	1	1	13	7	4	—	—	26
7/6/21 ...	5	—	—	2	14	20	6	—	1	43
20/10/21	5	—	1	—	—	5	—	—	—	6
7/6/21 ...	6	—	—	1	4	2	3	—	—	10
20/10/21	6 and +	2	2	3	9	4	—	—	—	20
7/6/21 ...	7 and +	—	2	4	11	8	3	1	—	29

FIFTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	22	23	24	25	26	27	28	29	Total.
7/6/21 ...	5	—	—	—	4	26	12	—	1	43
20/10/21	5	—	—	1	—	4	1	—	—	6
7/6/21 ...	6	—	—	—	2	4	4	—	—	10
20/10/21	6 and +	2	—	3	10	5	—	—	—	20
7/6/21 ...	7 and +	—	—	3	9	12	4	1	—	29

TABLE III. (Continued).

FIRTH OF FORTH SAMPLES.—FIRST YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings	5	6	7	8	9	10	11	12	13	14	Total.
10/2/21	3	1	1	1	14	20	42	38	22	7	2	148
9/2/22 ...	4	—	2	10	41	48	53	37	11	3	—	205
10/2/21	4	3	5	2	4	4	8	4	2	—	—	32
9/2/22	5	2	2	3	6	6	4	1	3	—	—	27
10/2/21	5	1	—	1	1	1	2	2	2	1	1	12
9/2/22 ...	6 and +	1	2	2	4	16	9	13	4	1	—	52
10/2/21	6 and +	—	2	1	1	9	7	9	3	3	2	37

SECOND YEAR GROWTH

CENTIMETRES.

Date.	Winter Rings.	12	13	14	15	16	17	18	19	20	21	22	23	24	Total.
10/2/21	3	—	—	—	—	—	6	20	29	52	34	7	—	—	148
9/2/22 ...	4	—	—	2	11	16	28	36	59	36	16	—	1	—	205
10/2/21	4	—	2	3	—	3	—	9	11	3	1	—	—	—	32
9/2/22 ...	5	1	—	2	3	6	3	4	5	1	—	1	—	1	27
10/2/21	5	—	—	2	—	—	1	2	1	3	3	—	—	—	12
9/2/22 ...	6 and +	—	—	1	1	3	4	8	12	15	4	4	—	—	52
10/2/22	6 and +	—	—	—	2	—	1	3	8	10	10	3	—	—	37

THIRD YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	19	20	21	22	23	24	25	26	27	Total.
10/2/21	3	—	—	—	12	30	54	36	14	2	148
9/2/22 ...	4	—	1	9	37	77	64	16	—	1	205
10/2/21	4	1	3	6	9	8	4	—	1	—	32
9/2/22 ...	5	1	7	5	3	4	5	—	1	—	27*
10/2/21	5	—	1	2	—	1	3	5	—	—	12
9/2/22 ...	6 and +	1	—	4	7	20	14	5	1	—	52
10/2/21	6 and +	—	1	—	1	6	17	11	1	—	37

* 1 under 29 cm.

TABLE III. (Continued).

FIRTH OF FORTH SAMPLES.—FOURTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	22	23	24	25	26	27	28	29	30	Total.
10/2/21	4	2	3	11	12	3	—	1	—	—	32
9/2/22 ...	4	—	12	50	99	40	3	1	—	—	205
10/2/21	5	—	1	2	1	2	5	1	—	—	12
9/2/22	5	1	6	8	7	2	2	—	—	1	27
10/2/21	6 and +	—	—	1	10	16	9	1	—	—	37
9/2/22	6 and +	—	3	6	25	14	4	—	—	—	52

FIFTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	24	25	26	27	28	29	30	31	Total.
10/2/21 ...	5	—	2	2	1	5	2	—	—	12
9/2/22 ...	5	3	8	10	2	2	1	—	1	27
10/2/21 ...	6 and +	—	1	8	16	10	2	—	—	37
9/2/22 ...	6 and +	1	6	18	20	7	—	—	—	52

TABLE III. (Continued).

FIRTH OF CLYDE SAMPLES.—FIRST YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	5	6	7	8	9	10	11	12	13	14	Total.
9/2/22 ...	3	—	—	1	1	1	3	4	1	—	—	11
2/3/22 ...	3	—	—	—	—	—	—	1	—	2	—	3
9/2/22 ...	4	—	—	2	3	4	6	6	6	1	1	29
2/3/22 ...	4	—	—	—	—	—	2	4	8	3	—	17
9/2/22 ...	5	1	—	10	26	31	41	45	24	8	3	189
2/3/22 ...	5	—	1	—	18	29	53	53	44	15	2	215
9/2/22 ...	6	—	—	—	2	2	2	5	2	—	—	13
2/3/22 ...	6 and 7	—	—	—	—	1	2	4	4	1	—	12

SECOND YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	13	14	15	16	17	18	19	20	21	22	23	Total.
9/2/22 ...	3	—	—	—	1	—	—	2	1	3	2	2	11
2/3/22 ...	3	—	—	—	—	—	—	—	—	3	—	—	3
9/2/22 ...	4	—	—	—	—	5	6	5	5	4	2	2	29
2/3/22 ...	4	—	—	—	—	—	1	5	1	5	3	2	17
9/2/22 ...	5	2	4	3	17	26	26	37	41	28	4	1	189
2/3/22 ...	5	—	2	3	20	24	38	30	52	38	6	2	215
9/2/22 ...	6	—	—	3	1	4	2	1	1	—	1	—	13
2/3/22 ...	6 and 7	—	—	—	—	2	2	2	2	3	—	1	12

THIRD YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	19	20	21	22	23	24	25	26	27	Total.
9/2/22 ...	3	—	—	—	—	3	1	2	3	2	11
2/3/22 ...	3	—	—	—	—	—	1	1	—	1	3
9/2/22 ...	4	—	—	—	3	9	5	6	3	3	29
2/3/22 ...	4	—	—	—	—	1	4	4	6	2	17
9/2/22 ...	5	2	7	30	34	46	46	20	4	—	189
2/3/22 ...	5	2	5	26	44	46	52	30	9	1	215
9/2/22 ...	6	—	2	3	4	1	2	1	—	—	13
2/3/22 ...	6 and 7	—	—	1	2	2	4	1	—	2	12

TABLE III. (Continued).

FIRTH OF CLYDE SAMPLES.—FOURTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	23	24	25	26	27	28	29	30	Total.
9/2/22 ...	4	1	1	5	8	4	6	4	—	29
2/3/22 ...	4	—	—	—	3	4	5	4	1	17
9/2/22 ...	5	6	35	57	67	19	5	—	—	189
2/3/22 ...	5	7	30	68	64	29	13	4	—	215
9/2/22 ...	6	3	3	3	2	1	1	—	—	13
2/3/22 ...	6 and 7	—	3	1	5	1	1	1	—	12

FIFTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	24	25	26	27	28	29	30	31	Total.
9/2/22 ...	5	—	12	47	82	39	9	—	—	189
2/3/22 ...	5	—	8	51	84	52	16	4	—	215
9/2/22 ...	6	1	2	5	3	1	1	—	—	13
2/3/22 ...	6 and 7	—	—	4	5	1	1	1	—	12

TABLE III. (Continued).

IRISH SEA SAMPLES.—ARDGLASS, HOWTH AND KILKEEL.

FIRST YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total.
28/6/21	2	—	—	—	—	2	3	10	14	29	8	4	2	—	—	72
6/8/21 ...	2	—	—	—	—	—	1	2	3	3	3	—	1	—	—	13
9/9/21 ...	2	—	—	—	3	4	5	7	4	7	—	—	—	—	—	30
22/10/21	2	—	—	—	1	4	6	7	16	30	20	8	1	—	1	94
28/6/21	3	—	1	6	12	23	16	14	14	5	6	3	1	—	—	101
6/8/21 ...	3	—	—	—	1	2	4	14	8	8	20	6	5	1	—	69
9/9/21 ...	3	—	—	1	—	—	1	2	4	1	1	1	—	—	—	11
22/10/21	3	1	6	17	11	17	18	6	10	5	4	1	—	—	—	96
28/6/21	4	—	—	1	—	1	3	—	2	—	4	1	—	—	—	12
6/8/21 ...	4	—	—	—	3	3	7	11	13	7	4	5	2	—	—	55
9/9/21 ...	4	—	—	—	3	1	3	7	3	6	9	3	2	—	—	37
22/10/21	4	—	1	4	6	3	3	1	—	1	2	—	—	—	—	21
28/6/21	5	—	—	—	1	—	2	2	3	1	1	2	1	—	—	13
6/8/21 ...	5	—	1	1	4	3	4	6	4	11	3	4	2	1	—	41
9/9/21 ...	5	—	—	1	1	6	9	7	11	13	9	8	2	—	—	67
22/10/21	5 and +	—	—	1	—	1	1	1	—	4	—	—	—	—	—	8
28/6/21	6 and +	—	—	—	1	2	2	2	1	1	1	2	—	—	—	12
6/8/21 ...	6 and +	—	—	2	6	7	1	2	2	3	2	1	1	—	—	27
9/9/21 ...	6 and +	—	—	3	5	4	4	12	7	5	1	2	1	—	—	44

TABLE III. (Continued)

IRISH SEA SAMPLES.—ARDGLASS, HOWTH AND KILKEEL.

SECOND YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	12	13	14	15	16	17	18	19	20	21	22	23	Total.
28/6/21	2	—	—	—	—	—	—	7	35	24	4	2	—	72
6/8/21 ...	2	—	—	—	—	1	1	3	2	3	2	—	1	13
9/9/21 ...	2	—	—	—	—	3	5	7	7	6	2	—	—	30
22/10/21	2	—	—	—	1	1	2	3	23	40	19	3	2	94
28/6/21	3	—	1	10	12	18	20	18	9	4	8	1	—	101
6/8/21 ...	3	—	—	—	—	1	4	11	12	17	18	4	2	69
9/9/21 ...	3	—	1	—	—	—	1	3	1	4	—	1	—	11
22/10/21	3	—	3	10	24	27	12	4	3	8	4	1	—	96
28/6/21	4	—	—	1	—	2	1	1	1	4	2	—	—	12
6/8/21 ...	4	—	—	1	1	4	6	10	11	11	10	1	—	55
9/9/21 ...	4	—	—	1	1	2	3	4	7	10	5	4	—	37
22/10/21	4	—	—	1	3	11	3	—	—	—	3	—	—	21
28/6/21	5	—	—	—	1	—	1	3	2	3	2	1	—	13
6/8/21 ...	5	1	—	—	3	4	6	7	7	11	2	3	—	44
9/9/21 ...	5	—	—	1	2	4	6	9	17	17	8	3	—	67
22/10/21	5 and +	—	—	—	2	—	1	1	1	1	1	1	—	8
28/6/21	6 and +	—	—	1	—	1	4	2	—	4	—	—	—	12
6/8/21 ...	6 and +	—	2	3	5	4	1	3	3	3	3	—	—	27
9/9/21 ...	6 and +	—	—	1	4	7	8	6	10	3	5	—	—	44

THIRD YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	19	20	21	22	23	24	25	26	Total.
28/6/21 ...	3	7	23	33	15	12	10	1	—	101
6/8/21 ...	3	—	1	2	6	16	27	12	5	69
9/9/21 ...	3	—	1	—	2	2	5	—	1	11
22/10/21 ...	3	1	17	35	25	11	5	2	—	96
28/6/21 ...	4	—	—	1	4	3	4	—	—	12
6/8/21 ...	4	—	—	1	8	25	16	5	—	55
9/9/21 ...	4	—	2	3	3	6	17	6	—	37
22/10/21 ...	4	—	1	8	7	3	2	—	—	21
28/6/21 ...	5	—	1	—	2	5	4	—	1	13
6/8/21 ...	5	2	1	6	12	12	9	2	—	44
9/9/21 ...	5	—	—	6	14	25	16	6	—	67
22/10/21 ...	5 and +	—	1	1	2	2	—	2	—	8
28/6/21 ...	6 and +	—	—	5	4	3	—	—	—	12
6/8/21 ...	6 and +	2	5	7	3	7	2	1	—	27
9/9/21 ...	6 and +	1	3	5	15	13	5	2	—	44

TABLE III. (Continued)

IRISH SEA SAMPLES.—ARDGLASS, HOWTH AND KILKEEL.

FOURTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	21	22	23	24	25	26	27	Total.
28/6/21	4	—	—	1	2	5	4	—	12
6/8/21 ...	4	—	—	1	2	25	24	3	55
9/9/21 ...	4	—	—	1	4	4	21	7	37
22/10/21	4	—	—	1	11	8	1	—	21
28/6/21	5	—	—	—	3	7	2	1	13
6/8/21 ...	5	—	1	2	11	21	7	2	44
9/9/21 ...	5	—	—	1	10	31	21	4	67
22/10/21	5 and +	—	—	2	2	2	1	1	8
28/6/21	6 and +	—	—	4	7	1	—	—	12
6/8/21 ...	6 and +	—	1	4	8	8	6	—	27
9/9/21 ...	6 and +	—	1	1	17	18	6	1	44

FIFTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	24	25	26	27	28	Total.
28/6/21 ...	5	—	2	7	4	—	13
6/8/21 ...	5	—	11	16	14	3	44
9/9/21 ...	5	—	6	29	24	8	67
22/10/21 ...	5 and +	1	2	2	2	1	8
28/6/21 ...	6 and +	3	6	3	—	—	12
6/8/21 ...	6 and +	2	7	13	5	—	27
9/9/21 ...	6 and +	1	9	24	9	1	44

TABLE III. (Continued).

IRISH SAMPLES.—DOWNINGS AND GALWAY.

FIRST YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	4	5	6	7	8	9	10	11	12	13	14	15	16	Total.
8/6/21 ...	2	—	—	—	—	1	—	1	—	—	—	—	—	—	2
13/12/21	2	—	—	2	—	3	1	5	5	6	7	3	1	1	34
8/6/21 ...	3	—	—	—	—	—	4	9	7	9	8	5	—	—	42
13/12/21	3	—	—	—	5	7	4	8	15	10	17	6	4	1	77
8/6/21 ...	4	—	1	1	2	1	—	3	3	6	2	2	—	—	21
13/12/21	4	1	1	4	7	5	10	5	6	5	7	2	1	—	54
8/6/21 ...	5	—	—	—	1	3	4	2	4	—	3	3	1	—	21
13/12/21	5	—	1	1	9	12	2	3	1	—	—	—	—	—	29
8/6/21 ...	6 and +	—	—	3	3	1	5	7	4	6	8	6	1	—	44
13/12/21	6 and +	—	1	1	—	2	2	—	1	1	1	—	—	—	9

SECOND YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	14	15	16	17	18	19	20	21	22	23	24	25	26	Total.
8/6/21 ...	2	—	—	—	—	—	1	—	—	1	—	—	—	—	2
13/12/21	2	—	—	—	—	2	1	5	9	7	9	—	—	1	34
8/6/21 ...	3	—	—	—	1	4	2	9	16	8	2	—	—	—	42
13/12/21	3	—	2	2	4	4	8	12	14	12	15	3	1	—	77
8/6/21 ...	4*	1	1	1	1	2	2	2	7	3	—	—	—	—	21
13/12/21	4	1	4	3	7	8	6	6	6	7	4	2	—	—	54
8/6/21 ...	5	—	1	3	1	1	4	4	2	2	1	2	—	—	21
13/12/21	5	1	2	4	12	5	4	—	1	—	—	—	—	—	29
8/6/21 ...	6 and +	1	6	1	3	3	7	10	4	7	2	—	—	—	44
13/12/21	6 and +	—	1	2	1	2	1	1	—	1	—	—	—	—	9

* 1 under 11 cm.

THIRD YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	Total.
8/6/21 ...	3	—	—	—	3	9	17	11	2	—	—	42
13/12/21	3	—	—	1	6	10	18	26	15	—	1	77
8/6/21 ...	4	—	1	1	6	2	8	3	—	—	—	21
13/12/21	4	—	—	—	9	10	19	13	3	—	—	54
8/6/21 ...	5	1	1	3	1	2	6	2	4	1	—	21
13/12/21	5	—	—	3	10	13	3	—	—	—	—	29
8/6/21 ...	6 and +	2	4	3	5	10	14	4	2	—	—	44
13/12/21	6 and +	—	—	2	4	1	1	1	—	—	—	9

TABLE III. (Continued).

IRISH SAMPLES.—DOWNINGS AND GALWAY.

FOURTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	23	24	25	26	27	28	29	30	Total
8/6/21 ...	4	—	1	1	6	6	6	1	—	21
13/12/21 ...	4	—	—	1	7	24	18	4	—	54
8/6/21 ...	5	—	2	2	3	4	5	3	2	21
13/12/21 ...	5	—	—	1	11	12	5	—	—	29
8/6/21 ...	6 and +	3	3	2	10	16	8	2	—	44
13/12/21 ...	6 and +	—	—	2	4	1	2	—	—	9

FIFTH YEAR GROWTH.

CENTIMETRES

Date.	Winter Rings.	24	25	26	27	28	29	30	31	Total.
8/6/21 ...	5	—	—	2	2	5	4	6	2	21
13/12/21 ...	5	—	—	—	5	14	7	3	—	29
8/6/21 ...	6 and +	1	2	2	9	17	9	4	—	44
13/12/21 ...	6 and +	—	—	1	2	4	2	—	—	9

TABLE III. (Continued).

LERWICK SAMPLE.—15 miles N.W. Ramna Stacks.

FIRST YEAR GROWTH.

CENTIMETRES.

Date	Winter Rings.	5	6	7	8	9	10	11	12	13	14	Total
7/6/22 ...	3	—	—	—	—	2	1	—	3	4	1	11
	4	—	—	1	4	2	5	12	6	1	—	31
	5	4	8	9	18	22	13	12	6	6	3	101
	6	—	—	2	4	4	2	4	—	2	—	18
	7 and +	2	—	6	5	2	6	8	1	—	1	31

SECOND YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	12	13	14	15	16	17	18	19	20	21	22	Total.
7/6/22 ...	3	—	—	—	—	—	—	1	3	3	3	1	11
	4	—	—	—	—	3	5	4	5	5	9	—	31
	5	3	7	8	9	18	11	13	14	12	4	2	101
	6	—	—	—	5	3	1	6	1	—	1	1	18
	7 and +	1	2	1	4	5	4	7	3	3	1	—	31

THIRD YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	17	18	19	20	21	22	23	24	25	26	Total.
7/6/22 ...	3	—	—	—	—	—	2	1	5	1	2	11
	4	—	—	—	—	3	6	5	12	5	—	31
	5	—	1	4	16	20	21	19	12	5	3	101
	6	—	—	—	1	4	6	4	2	1	—	18
	7 and +	1	—	3	2	9	4	9	3	—	—	31

TABLE III. (Continued).

LERWICK SAMPLES. 15 miles N.W. Ramna Stacks

FOURTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	22	23	24	25	26	27	28	Total
7/6/22 ...	4	—	2	6	9	7	6	1	31
	5	1	15	31	27	16	8	3	101
	6	—	3	6	5	3	1	—	18
	7 and +	2	9	7	11	2	—	—	31

FIFTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	23	24	25	26	27	28	29	Total.
7/6/22 ...	5	1	5	17	35	27	10	6	101
	6	—	—	6	5	5	2	—	18
	7 and +	—	6	11	8	6	—	—	31

II.—SIZE.

By DOROTHY COWAN.

In Table I. is given an analysis of the size of the herring samples examined during the past year. The size is, as in previous years, expressed to the nearest centimetre, 20·6 to 21·5 being taken as 21 cm.

It has not been considered necessary to give in Table II. all the samples in detail, as this would mean duplicating data already given in years past. An analysis of size for age is given for those that are thought to be the most important samples, and those from grounds not previously sampled. The latter include the samples from Great Yarmouth in June and October, Lerwick, June, 1922, Firth of Clyde, Irish Sea, north-west of Ireland, June, 1921, and Galway Bay. As the Wick sample of 18th March was caught off the Butt of Lewis, and this is the first sample of spring spawners from these grounds, data for this sample are included.

Data as to the origin of the samples will be found in the list given by Mr. Storrow (page 13).

The most northerly samples were from Lerwick. The first of these was caught 2nd July from 25 miles south from Bressay. The majority of the fish were from 27 to 29 cm. in length, and were fish principally at stages II. and III. This sample is interesting when compared with the second sample from the same port, caught 24th August, 8 miles E.S.E. from Bressay. The August sample, as will be seen from Table I. of Mr. Storrow's paper, was very similar in age composition to the July sample, but the size was larger. Large numbers of fish were under 28 and 29 cm., but there was 27 per cent. at 30 cm. A comparison of the samples is given below, and the difference in size will be seen to be most marked in fish with five and more winter rings. The August sample (II.) consisted of spawning fish and spents.

CENTIMETRES.

Station.	Date.	Winter Rings.	23	24	25	26	27	28	29	30	31	32	Total.
Lerwick I ...	... 2/7/21 ...	3	1	1	3	7	6	3	1	—	—	—	22
Lerwick II....	... 24/8/21 ...	3	—	—	6	9	2	6	1	—	—	—	24
Lerwick I. ...	... 2/7/21 ...	4	—	—	3	8	7	10	1	—	—	—	29
Lerwick II....	... 24/8/21 ...	4	—	3	2	9	8	5	3	1	—	—	31
Lerwick I. ...	... 2/7/21 ...	5	—	—	2	10	7	11	11	2	—	—	43
Lerwick II....	... 24/8/21 ...	5	—	—	—	3	6	11	9	13	1	1	44
Lerwick I. ...	... 2/7/21 ...	6	—	—	—	—	2	9	6	2	—	—	19
Lerwick II....	... 24/8/21 ...	6	—	—	—	4	2	1	4	5	1	—	17
Lerwick I. ...	... 2/7/21 ...	7	—	—	1	5	10	7	6	4	—	—	33
Lerwick II....	... 24/8/21 ...	7	—	—	—	1	1	6	12	14	4	1	39
Lerwick I. ...	... 2/7/21 ...	8	—	—	—	1	4	8	8	9	—	1	31
Lerwick II....	... 24/8/21 ...	8	—	—	—	—	—	1	5	9	4	—	19
Lerwick I. ...	... 2/7/21 ...	9	—	—	—	—	1	4	8	2	1	—	16
Lerwick II....	... 24/8/21 ...	9	—	—	—	—	1	1	2	8	2	—	14

Sample III., Lerwick, from 8 miles N.N.E. of Lamba Ness, 4th March, 1922, was from a spawning shoal. It contained many old fish, the majority of which had six to nine winter rings. It was a large sample for size, most of the fish being between 31 and 33 cm.

The last sample from Lerwick was taken on 7th June, 1922, from 15 miles N.W. of the Ramna Stacks. It was a sample of spent fish, and these fish were smaller in size than those of 4th March, and also younger (page 29). In size these fish were from 26 to 28 cm., and a comparison of the data given in Table II. will show that the age was not the determining factor as regards size.

The first sample from Wick was taken on 23rd August from 3 miles from Clyth Ness. It was a small sample for size, most of the fish grouping themselves at 24, 25 and 26 cm.

The February sample from Wick was caught 7 to 8 miles west by north of Whiten Head. As will be seen from Table I. most of the fish were from 28 to 31 cm., but the number under 30 cm. was less than that under 29 or 31 cm. This is accounted for by the size and number of fish with six, seven and eight winter rings, the data for which are as follows :—

CENTIMETRES.

Winter Rings.	28	29	30	31	32	33	Total.
6	3	2	6	9	5	—	25
7	—	—	—	5	1	—	6
8 and +	—	—	2	13	15	3	33

On the 17th February and the 18th March samples came from 10 miles from Cape Wrath, and 14 to 15 miles N.W. by N. from Butt of Lewis respectively. These samples were unlike. The Butt of Lewis sample had fewer fish with four winter rings, and more fish with seven to nine winter rings. The majority of the fish in the Cape Wrath sample came between 27 and 29 cm., whilst the Butt of Lewis sample contained many fish between 31 and 33 cm., and had 14 per cent. under 28 cm. As will be seen from the following data this difference in size is not so apparent in the younger fish with four winter rings, but the larger growth is evident in the fish of six, seven and eight winter rings.

CENTIMETRES.

Station.	Date.	Rings, Winter	26	27	28	29	30	31	32	33	34	Total.
Wick III. ...	17/2/22 ...	4	5	36	44	20	4	—	—	—	—	109
Wick IV. ...	18/3/22 ...	4	1	18	21	7	1	—	—	—	—	48
Wick III. ...	17/2/22 ...	5	—	2	9	14	7	3	—	—	—	35
Wick IV. ...	18/3/22 ...	5	—	—	3	13	6	1	1	—	—	24
Wick III. ...	17/2/22 ...	6	—	—	1	8	10	5	—	—	—	24
Wick IV. ...	18/3/22 ...	6	—	—	1	—	4	9	8	5	1	28
Wick III. ...	17/2/22 ...	7	—	—	—	3	—	3	4	—	—	10
Wick IV. ...	18/3/22 ...	7	—	—	—	—	1	4	11	1	—	17
Wick III. ...	17/2/22 ...	8	—	—	—	4	4	8	4	—	—	20
Wick IV. ...	18/3/22 ...	8	—	—	—	—	2	7	16	16	1	42

The Peterhead sample of August was from 5 miles east of Kinnaird Head. The size ranged principally from 26 to 29 cm. Further data will be found in Table I.

Only one sample was examined from the Firth of Forth, and that was caught 9th February, 1922, between Burntisland and Alloa. The fish were, generally speaking, a year older than in last year's sample, and the size ranged chiefly from 24 to 26 cm., with small numbers under 28 and 29 cm. The smaller fish had much the same growth, if allowance be made for their being a year older, as was found in the sample from the same grounds in 1921. A comparison of the size of fish from the year-classes here follows:—

CENTIMETRES.

Station.	Date.	Winter Rings.	22	23	24	25	26	27	28	29	Total.
Firth of Forth ...	10/2/21 ...	3	12	30	54	36	14	2	—	—	148
Firth of Forth ...	9/2/22 ...	4	—	12	50	99	40	3	1	—	205
Firth of Forth ...	10/2/21 ...	4	2	3	11	12	3	—	1	—	32
Firth of Forth ...	9/2/22 ...	5	—	—	3	8	10	2	2	1	27*

* 1 under 31 cm.

Of the five samples from Yarmouth one came from the mid-summer fishery, and the others from the October-December fishery of full fish. The first sample, 7th June, from 11 miles E.S.E. from Yarmouth, was composed principally of fish with four and five winter rings. The size ranged from 26 to 28 cm. The two samples taken 20th and 27th October from 11 miles N.N.E. from North Haisborough Light and 12½ miles east by north of Yarmouth respectively, were very similar in size. Most of the fish were from 24 to 26 cm., but the latter sample had more fish at 26 cm. and larger. This was due to a slight increase in the number of fish with five winter rings.

The 29th November and 15th December were the dates when the last two samples were taken. They both had the majority of the fish between 26 and 28 cm.

These samples contained older fish than those of October, but this does not account fully for the difference in size. The following data show that the November herrings had a larger size for age than those from the sample of 27th October.

CENTIMETRES.

Station.	Winter Rings.	21	22	23	24	25	26	27	28	29	30	Total.
Yarmouth III. ...	3	1	—	17	30	22	5	—	—	—	—	75
Yarmouth IV. ...	3	—	—	—	3	1	2	1	—	—	1	8
Yarmouth III. ...	4	—	—	1	2	15	20	2	—	—	—	40
Yarmouth IV. ...	4	—	—	—	—	7	7	6	2	1	—	23
Yarmouth III. ...	5	—	—	—	1	7	17	10	3	—	—	38
Yarmouth IV. ...	5	—	—	—	—	2	13	17	9	5	—	46
Yarmouth III. ...	6	—	—	—	—	—	2	1	4	2	—	9
Yarmouth IV. ...	6	—	—	—	—	—	1	1	8	5	1	16
Yarmouth III. ...	7	—	—	—	—	—	3	5	3	2	—	13
Yarmouth IV. ...	7	—	—	—	—	—	1	10	14	2	—	27

The Girvan samples, taken 9th February and 2nd March, were much alike, the size ranging principally from 26 to 28 cm., and the largest number were under 27 cm. As will be seen on page 29, they were for the most part fish with five winter rings.

All the Irish samples are worth considering, as this is the first year that any quantity of Irish herrings has been examined. Size for age data are given for all the samples.

Sample I. from Ardglass, 28th June, had most fish at 22 and 23 cm. The second sample from 25 miles S.E. by S. of Ardglass, 6th August, contained larger fish: the majority of them were from 26 to 28 cm. long. The age composition of these samples will be found on page 29, and it will be seen that the August samples contained older fish than that of June, and fewer fish with two and three winter rings. This difference in age does not account fully for the difference in size. Fish with three and four winter rings in the August sample were larger fish than those of similar age in the June sample.

			CENTIMETRES.							
Station.	Date.	Winter Rings.	21	22	23	24	25	26	27	28	Total.
Ardglass I.	... 28/6/21 ...	3	6	23	35	17	16	4	—	—	101
Ardglass II.	... 6/8/21 ...	3	—	—	2	4	24	25	10	4	69
Ardglass I.	... 28/6/21 ...	4	—	—	—	1	2	6	3	—	12
Ardglass II.	... 6/8/21 ...	4	—	—	—	—	2	15	30	8	55

Only one sample was examined from Kilkeel, and that was taken 22nd October from 1 mile south of Kilkeel harbour. In size and age it resembled sample I. from Ardglass. Most of the fish were from 22 to 25 cm. long, but the numbers at 24 and 25 cm. were greater than in the Ardglass sample of June. This difference was caused by the size of the fish with two and three winter rings in the Kilkeel sample, but it is most obvious for the younger year-class. The data for the size of fish with two winter rings are as follows :—

			CENTIMETRES.						
Station.	Date.	Winter Rings.	20	21	22	23	24	25	Total.
Ardglass I	... 28/6/21 ...	2	—	12	44	13	3	—	72
Kilkeel ...	... 22/10/21	2	1	5	29	30	23	6	94

The Kilkeel sample was composed of spawning fish, and the June Ardglass sample was one of developing fish and virgins.

The Howth sample, taken 9th September, 18 miles E.N.E. from Howth harbour, gives an interesting curve for size. The curve has two maxima, a small one under 22 cm., and a larger one under 27 and 28 cm.

Reference to Table II. will show that this is due to the small number of fish with three winter rings found in this sample. It is worth notice that although the fish with two and three winter rings are similar in size to the June Ardglass and the Kilkeel sample, the fish with four winter rings are decidedly larger. The following data show this difference :—

			CENTIMETRES.						
Station	Date.	Winter Rings.	24	25	26	27	28	29	Totals.
Ardglass I.	... 28/6/21 ...	4	1	2	6	3	—	—	12
Ardglass II.	... 6/8/21 ...	4	—	2	15	30	8	—	55
Kilkeel ...	... 22/10/21	4	1	9	10	1	—	—	21
Howth ...	... 9/9/21 ...	4	—	1	5	18	11	2	37

As will be seen from Mr. Storrow's Table II., Maturity, this sample was, for the most part, composed of spawning fish.

The Galway Bay sample was taken 13th December, and shows a decided contrast with the sample from the Irish Sea. Although composed chiefly of young fish, most of them having three and four winter rings, and 16 per cent. with only two winter rings, they were large fish. Table I. shows that the greatest numbers of fish were from 28 to 29 cm. in length, and a fair number at 30 cm. These fish were for the most part spents.

In the Downings sample there are two distinct cusps in the size data. The first is at 27 cm., and the second occurs at 30 cm. There were twenty fish out of 130 which had attained a greater size than 30 cm. Reference to Table II. will show that the data for size is influenced by the age composition of the sample. This sample contained larger herring than that from Galway Bay, but the difference is probably due to the Downings sample containing more of the older fish. The sizes of fish with three winter rings given below show the Galway Bay herrings are larger.

			CENTIMETRES.								
Station.		Winter Rings.	24	25	26	27	28	29	30	31	Total.
Downings	...	3	—	4	16	16	5	1	—	—	42
Galway Bay	...	3	1	—	10	23	35	7	—	1	77

Two samples were examined from Buncrana. The first was taken 24th January from 8 miles north from the mouth of Lough Swilly, and the second, 4th March, from 25 miles from Lough Swilly. The first sample contained the largest herrings yet examined from Irish waters, there being 22 per cent. at 31 cm., 31 per cent. at 32 cm., and 18 per cent. at 33 cm. As will be seen from Table I. in Mr. Storrow's paper, the fish were principally fish with four, five, six and eight winter rings. Both samples were mature fish: the first consisted of fish at stage V., and the second sample came from a spawning shoal. The age composition of the March sample resembled that of the January, except that there were rather more fish with three winter rings.

Attention was drawn in last year's report to the difference in size of the samples of spring spawning herrings from Buncrana, and the samples of this year further indicate the possibility of there being shoals off the north-west coast of Ireland having different growths. The samples when compared as below show that the January shoals consisted of larger fish than were caught in March.

CENTIMETRES.

Station.	Date.	Winter Rings.	26	27	28	29	30	31	32	33	34	Total.
Buncrana I. ...	24/1/22 ...	3	—	—	2	1	—	—	—	—	—	3
Buncrana II. ...	4/3/22 ...	3	5	10	3	4	—	—	—	—	—	22
Buncrana I. ...	24/1/22 ...	4	—	1	4	5	17	8	2	—	—	37
Buncrana II. ...	4/3/22 ...	4	2	6	18	16	12	5	—	—	—	59
Buncrana I. ...	24/1/22 ...	5	—	—	3	5	11	14	10	—	—	43
Buncrana II. ...	4/3/22 ...	5	—	—	4	10	18	8	—	—	—	40
Buncrana I. ...	24/1/22 ...	6	—	—	—	—	—	16	22	7	2	47
Buncrana II. ...	4/3/22 ...	6	—	—	—	—	11	7	8	4	—	30
Buncrana I. ...	24/1/22 ...	7	—	—	—	—	—	2	6	6	—	14
Buncrana II. ...	4/3/22 ...	7	—	—	—	—	1	4	6	—	—	11
Buncrana I. ...	24/1/22 ...	8	—	—	—	—	—	—	15	13	1	29
Buncrana II. ...	4/3/22 ...	8	—	—	—	—	3	12	6	3	—	24

When comparing the size of the herrings from the samples examined in 1919-20 it was shown that the more northerly shoals had a more rapid growth than those further south. The Irish samples yield further evidence of oceanic herrings having a quicker growth than those from narrower and shallower waters.

TABLE I.—SIZE.

CENTIMETRES.

Sample.		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1921.																	
Lerwick I.	Nos. ...	—	—	—	—	1	1	9	31	37	54	44	19	1	1	—	—
	% ...	—	—	—	—	0·5	0·5	4·5	15·6	18·7	27·2	22·2	9·7	0·5	0·5	—	—
Lerwick II.	Nos. ...	—	—	—	—	—	3	8	27	20	31	36	53	15	2	—	—
	% ...	—	—	—	—	—	1·5	4·1	13·8	10·2	15·9	18·5	27·2	7·7	1·0	—	—
Wick I.	Nos. ...	—	—	—	3	15	41	43	53	20	13	12	9	—	—	—	—
	% ...	—	—	—	1·4	7·2	19·6	20·6	25·4	9·6	6·2	5·7	4·3	—	—	—	—
Peterhead	Nos. ...	—	—	—	—	1	3	20	28	32	52	38	23	5	—	—	—
	% ...	—	—	—	—	0·5	1·5	9·9	13·8	15·9	25·7	18·8	11·4	2·5	—	—	—
Great Yarmouth I. ...	Nos. ...	—	—	—	—	—	—	6	33	49	31	7	2	—	—	—	—
	% ...	—	—	—	—	—	—	4·7	25·8	38·2	24·2	5·5	1·6	—	—	—	—
Great Yarmouth II. ...	Nos. ...	—	—	—	1	14	39	34	21	11	8	5	1	—	—	—	—
	% ...	—	—	—	0·7	10·5	29·1	25·4	15·7	8·2	6·0	3·7	0·7	—	—	—	—
Great Yarmouth III.	Nos. ...	—	—	1	1	19	34	44	48	20	14	4	1	—	—	—	—
	% ...	—	—	0·5	0·5	10·2	18·2	23·6	25·8	10·7	7·5	2·2	0·5	—	—	—	—
Great Yarmouth IV.	Nos. ...	—	—	—	—	—	3	12	24	44	42	16	1	—	—	—	—
	% ...	—	—	—	—	—	2·1	8·4	16·9	31·0	29·6	11·3	0·7	—	—	—	—
Great Yarmouth V. ...	Nos. ...	—	—	—	—	—	—	8	20	41	33	18	1	—	—	—	—
	% ...	—	—	—	—	—	—	5·9	21·4	30·4	28·2	13·4	0·7	—	—	—	—
Ardglass I.	Nos. ...	—	—	18	67	48	21	19	20	11	6	—	—	—	—	—	—
	% ...	—	—	8·6	31·9	22·8	10·0	9·1	9·5	5·2	2·9	—	—	—	—	—	—
Ardglass II.	Nos. ...	—	1	1	2	6	8	26	55	72	36	1	—	—	—	—	—
	% ...	—	0·5	0·5	1·0	2·9	3·8	12·5	26·4	34·6	17·3	0·5	—	—	—	—	—
Kilkeel	Nos. ...	—	2	5	41	66	47	30	21	2	4	1	—	—	—	—	—
	% ...	—	0·9	2·3	18·7	30·1	21·4	13·7	9·7	0·9	1·8	0·9	—	—	—	—	—

TABLE I.—SIZE (continued).

CENTIMETRES.

Sample.		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1921.																	
Howth...	Nos. ...	1	3	8	14	6	3	3	21	58	62	12	—	1	—	—	—
	% ...	0·5	1·6	4·2	7·3	3·1	1·6	1·6	11·0	30·2	32·2	6·2	—	0·5	—	—	—
Galway	Nos. ...	—	—	—	—	6	6	9	25	28	64	46	18	5	1	—	—
	% ...	—	—	—	—	2·9	2·9	4·3	12·0	13·5	30·7	22·2	8·6	2·4	0·5	—	—
Downings	Nos. ...	—	—	—	—	1	—	5	18	24	17	14	31	16	4	—	—
1922	% ...	—	—	—	—	0·8	—	3·8	13·8	18·5	13·1	10·8	23·8	12·3	3·1	—	—
Lerwick III	Nos. ...	—	—	—	—	—	—	1	2	6	26	14	7	27	45	32	8
	% ...	—	—	—	—	—	—	0·6	1·2	3·6	15·5	8·3	4·2	16·1	26·8	19·0	4·8
Lerwick IV	Nos. ...	—	—	—	1	3	16	26	52	47	27	19	3	—	—	—	—
	% ...	—	—	—	0·5	1·5	8·3	13·4	26·8	24·2	13·9	9·8	1·5	—	—	—	—
Wick II.	Nos. ...	—	—	—	—	—	—	—	4	14	30	33	25	32	21	3	—
	% ...	—	—	—	—	—	—	—	2·5	8·6	18·5	20·4	15·4	19·7	13·0	1·9	—
Wick III.	Nos.	—	—	—	—	—	—	—	5	39	54	50	25	20	11	2	1
	% ...	—	—	—	—	—	—	—	2·4	18·8	26·0	24·1	12·1	9·7	5·3	1·0	0·5
Wick IV.	Nos. ...	—	—	—	—	—	—	—	1	18	25	20	15	24	41	29	3
	% ...	—	—	—	—	—	—	—	0·6	10·2	14·2	11·3	8·5	13·6	23·3	16·5	1·7
Firth of Forth ...	Nos. ...	1	1	—	—	16	58	109	51	10	20	24	5	3	—	—	—
	% ...	0·3	0·3	—	—	5·4	19·4	36·6	17·1	3·4	6·7	8·0	1·7	1·0	—	—	—
Girvan I.	Nos. ...	—	—	—	—	4	2	20	59	95	48	14	1	1	—	—	—
	% ...	—	—	—	—	1·6	0·8	8·2	24·2	39·0	19·7	5·7	0·4	0·4	—	—	—
Girvan II.	Nos. ...	—	—	—	—	—	1	9	54	93	62	21	6	1	—	—	—
	% ...	—	—	—	—	—	0·4	3·7	21·8	37·6	25·1	8·5	2·4	0·4	—	—	—
Buncrana I.	Nos. ...	—	—	—	—	—	—	—	—	1	9	11	28	41	58	34	4
	% ...	—	—	—	—	—	—	—	—	0·5	4·8	5·9	15·1	22·1	31·2	18·3	2·1
Buncrana II.	Nos. ...	—	—	—	—	—	—	—	7	16	25	30	45	40	23	8	—
	% ...	—	—	—	—	—	—	—	3·6	8·2	12·9	15·5	23·3	20·6	11·8	4·1	—

TABLE II.—SIZE FOR AGE.

CENTIMETRES.

Sample.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total.
Lerwick 3 ...	3	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
	4	—	—	—	—	—	1	2	5	17	5	1	—	—	—	—	31
	5	—	—	—	—	—	—	—	—	7	9	—	1	2	—	—	19
	6	—	—	—	—	—	—	—	—	2	—	5	8	7	5	—	27
	7	—	—	—	—	—	—	—	—	—	—	—	7	7	4	1	19
	8	—	—	—	—	—	—	—	—	—	—	1	9	19	19	3	51
	9	—	—	—	—	—	—	—	—	—	—	—	2	10	4	1	17
	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
		—	—	—	—	—	1	2	6	26	14	7	27	45	32	8	168
Lerwick 4 ...	2	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	2
	3	—	—	1	1	2	3	2	2	—	—	—	—	—	—	—	11
	4	—	—	—	1	7	6	9	7	1	—	—	—	—	—	—	31
	5	—	—	—	1	5	17	35	26	11	6	—	—	—	—	—	101
	6	—	—	—	—	—	—	5	6	5	2	—	—	—	—	—	18
	7	—	—	—	—	—	—	—	4	3	2	—	—	—	—	—	9
	8	—	—	—	—	—	—	1	2	3	3	—	—	—	—	—	9
	9	—	—	—	—	—	—	—	—	2	2	3	—	—	—	—	7
	10	—	—	—	—	—	—	—	—	2	2	—	—	—	—	—	4
	12	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
	14	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
		—	—	1	3	16	26	52	47	27	19	3	—	—	—	—	194
Wick 4	4	—	—	—	—	—	—	1	18	21	7	1	—	—	—	—	48
	5	—	—	—	—	—	—	—	—	3	13	6	1	1	—	—	24
	6	—	—	—	—	—	—	—	—	1	—	4	9	8	5	1	28
	7	—	—	—	—	—	—	—	—	—	—	1	4	11	1	—	17
	8	—	—	—	—	—	—	—	—	—	—	2	7	16	16	1	42
	9	—	—	—	—	—	—	—	—	—	—	1	3	4	6	—	14
	10	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	3
		—	—	—	—	—	—	1	18	25	20	15	24	41	29	3	176
Firth of Forth ...	2*	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
	3	—	—	—	4	5	2	1	—	—	—	—	—	—	—	—	12
	4	—	—	—	12	50	99	40	3	1	—	—	—	—	—	—	205
	5	—	—	—	—	3	8	10	2	2	1	—	1	—	—	—	27
	6	—	—	—	—	—	—	—	3	3	4	1	—	—	—	—	11
	7	—	—	—	—	—	—	—	1	2	3	—	—	—	—	—	6
	8	—	—	—	—	—	—	—	1	7	5	—	—	—	—	—	13
	9	—	—	—	—	—	—	—	—	4	8	—	1	—	—	—	13
	10	—	—	—	—	—	—	—	—	—	3	2	—	—	—	—	5
	11	—	—	—	—	—	—	—	1	—	—	1	1	—	—	—	3
	12	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
		*1	—	—	16	58	109	51	10	20	24	5	3	—	—	—	298

* One fish at 19 cm

TABLE II.—(Continued).

CENTIMETRES.

Samples.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total.
Gt. Yarmouth I.	3	—	—	—	—	—	2	2	3	—	—	—	—	—	—	—	7
	4	—	—	—	—	—	3	17	13	5	1	—	—	—	—	—	39
	5	—	—	—	—	—	1	12	22	7	—	1	—	—	—	—	43
	6	—	—	—	—	—	—	1	4	5	—	—	—	—	—	—	10
	7	—	—	—	—	—	—	1	4	6	3	—	—	—	—	—	14
	8	—	—	—	—	—	—	—	3	6	3	—	—	—	—	—	12
	9	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	2
	10	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
		—	—	—	—	—	6	33	49	31	7	2	—	—	—	—	128
Gt. Yarmouth II.	2	—	—	—	5	2	2	—	—	—	—	—	—	—	—	—	9
	3	—	—	1	9	34	22	7	—	—	—	—	—	—	—	—	73
	4	—	—	—	—	3	9	11	3	—	—	—	—	—	—	—	26
	5	—	—	—	—	—	1	—	4	1	—	—	—	—	—	—	6
	6	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	2
	7	—	—	—	—	—	—	—	3	3	1	—	—	—	—	—	7
	8	—	—	—	—	—	—	2	—	3	1	—	—	—	—	—	6
	9	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	3
	11	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
	12	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
		—	—	1	14	39	34	21	11	8	5	1	—	—	—	—	134
Gt. Yarmouth III.	2	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	3
	3	—	1	—	17	30	22	5	—	—	—	—	—	—	—	—	75
	4	—	—	—	1	2	15	20	2	—	—	—	—	—	—	—	40
	5	—	—	—	—	1	7	17	10	3	—	—	—	—	—	—	38
	6	—	—	—	—	—	—	2	1	4	2	—	—	—	—	—	9
	7	—	—	—	—	—	—	3	5	3	2	—	—	—	—	—	13
	8	—	—	—	—	—	—	1	1	3	—	1	—	—	—	—	6
	9	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
	10	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
		—	1	1	19	34	44	48	20	14	4	1	—	—	—	—	186
Girvan I.	3	—	—	—	3	1	2	3	2	—	—	—	—	—	—	—	11
	4	—	—	—	1	1	5	8	4	6	4	—	—	—	—	—	29
	5	—	—	—	—	—	12	47	82	39	9	—	—	—	—	—	189
	6	—	—	—	—	—	1	1	6	3	1	—	1	—	—	—	13
	8	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	2
		—	—	—	1	2	20	59	95	48	14	1	1	—	—	—	244
Girvan II.	3	—	—	—	—	1	1	—	1	—	—	—	—	—	—	—	3
	4	—	—	—	—	—	—	3	4	5	4	1	—	—	—	—	17
	5	—	—	—	—	—	8	51	84	52	16	4	—	—	—	—	215
	6	—	—	—	—	—	—	—	4	5	1	1	—	—	—	—	11
	7	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
		—	—	—	—	1	9	54	93	62	21	6	1	—	—	—	247

TABLE II.—(Continued).

IRISH SAMPLES.

CENTIMETRES.

Sample.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total.
Ardglass I. ...	2	—	12	44	13	3				—		—	—			—	72
	3	—	6	23	35	17	16	4	—	—		—			—		101
	4	—	—	—	—	1	2	6	3			—					12
	5	—		—	—	—	—	6	5	2		—				—	13
	6	—	—	—	—		1	3		1		—	—		—	—	5
	7	—	—				—	1	2	1		—					4
	8	—	—	—		—	—		1	1		—	—			—	2
	10	—	—	—	—			—	—	1		—	—	—		—	1
		—	18	67	48	21	19	20	11	6		—				—	210
Ardglass II. ...	2	1	1	2	4	4		1		—	—	—	—			—	13
	3	—	—	—	2	4	24	25	10	4	—	—		—		—	69
	4	—	—	—	—	—	2	15	30	8	—	—	—			—	55
	5	—	—	—	—	—	—	10	21	13	—	—	—	—	—	—	44
	6	—		—	—	—	—	3	6	8	1	—	—	—			18
	7	—	—	—	—		—	1	4	2	—	—	—	—	—	—	7
	8	—	—	—	—	—	—		1	1	—	—	—	—		—	2
		1	1	2	6	8	26	55	72	36	1	—			—		208
Kilkeel	2	1	5	29	30	23	6	—				—	—	—			94
	3	1	—	12	36	23	14	10	—			—					96
	4	—	—			1	9	10	1			—					21
	5	—	—	—			1	1	1		1	—					4
	6	—	—	—	—	—	—	—		1		—		—			1
	7	—	—	—	—		—	—		2		—	—			—	2
	8	—	—	—	—	—	—	—	—	1		—					1
		2	5	41	66	17	30	21	2	4	1	—					219
Howth	1	*1	1	—								—					3
	2	2	7	14	5	2						—					30
	3	—	—		1	1	2	5	1	1		—					11
	4	—	—	—	—	—	1	5	18	11	2	—				—	37
	5	—	—	—		—		9	29	25	4	—					67
	6	—	—	—				2	5	7	3	—	—		—		17
	7	—	—				—	—	3	14	2	—					19
	8	—	—	—	—	—			2	2	1	—	1				6
	10	—	—	—						1		—	—				1
	11	—	—		—		—	—	—	1		—					1
		*3	8	14	6	3	3	21	58	62	12	—	1	—	—		192
Galway	1	—	—	—	5	—						—					5
	2	—	—	—	1	5	9	14	1	1		—					31
	3	—	—	—	—	1		10	23	35	7	—	1			—	77
	4	—	—	—	—	—	—	1	1	21	25	6				—	54
	5	—	—	—	—			—	—	6	14	7	2	—			29
	6	—	—	—	—	—	—	—	—	1	—	2	1		—	—	4
	7	—	—	—	—	—	—	—	—			3	—	1		—	4
	8	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
		—	—	—	6	6	9	25	28	61	46	18	5	1	—	—	205

* One fish at 19 cm.

TABLE II.—(Continued).

CENTIMETRES.

Sample.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Tot.
Dowdings ...	2	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	1
	3	—	—	—	—	—	4	16	16	5	1	—	—	—	—	—	42
	4	—	—	—	—	—	1	1	5	8	4	2	—	—	—	—	21
	5	—	—	—	—	—	—	—	3	3	3	7	3	2	—	—	21
	6	—	—	—	—	—	—	—	—	—	2	4	4	—	—	—	10
	7	—	—	—	—	—	—	—	—	1	1	13	5	1	—	—	21
	8	—	—	—	—	—	—	—	—	—	2	3	3	1	—	—	9
...	9	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	3
	10	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
		—	—	—	1	—	5	18	24	17	14	31	16	4	—	—	130
Bunerana I. ...	3	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	3
	4	—	—	—	—	—	—	—	1	4	5	17	8	2	—	—	37
	5	—	—	—	—	—	—	—	—	3	5	11	14	10	—	—	43
	6	—	—	—	—	—	—	—	—	—	—	—	16	22	7	2	47
	7	—	—	—	—	—	—	—	—	—	—	—	2	6	6	—	14
	8	—	—	—	—	—	—	—	—	—	—	—	—	15	13	1	29
	9	—	—	—	—	—	—	—	—	—	—	—	1	1	6	1	9
	10	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	3
	11	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
		—	—	—	—	—	—	—	1	9	11	28	41	58	34	4	186
Bunerana II ...	3	—	—	—	—	—	5	10	3	4	—	—	—	—	—	—	22
	4	—	—	—	—	—	2	6	18	16	12	5	—	—	—	—	59
	5	—	—	—	—	—	—	—	4	10	18	8	—	—	—	—	40
	6	—	—	—	—	—	—	—	—	—	11	7	8	4	—	—	30
	7	—	—	—	—	—	—	—	—	—	1	4	6	—	—	—	11
	8	—	—	—	—	—	—	—	—	—	3	12	6	3	—	—	24
	9	—	—	—	—	—	—	—	—	—	—	—	4	1	—	—	5
	10	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	2
	12	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
		—	—	—	—	—	—	7	16	25	30	45	40	23	8	—	194

NOTES SUGGESTIVE OF FURTHER WORK IN HERRING INVESTIGATIONS.

By B. STORROW.

For some years now it has been the writer's opinion that the most important result to be obtained from herring investigations was a knowledge of the fluctuations of the fishery, and that before any step towards the solution of fluctuations was possible the available facts with regard to age composition and migrations of shoals needed considerable additions. Other questions, doubtless, deserve consideration, but those mentioned have occupied the greater part of the past two winters. Whilst it cannot be claimed that any definite conclusions of value have been reached, a number of facts and coincidences have been accumulated which are suggestive of further work. The chief of these are set forth below.

Age.—The herring becomes of commercial importance when it has three winter rings on its scales, that is, it is in its fourth year. Samples examined from the North Sea, from Wick to Scarborough, showed that the summer feeding shoals of developing herrings contained from 50 to 70 per cent. of fish of this age.* Samples from the Irish Sea and the north-west of Ireland also showed the importance of fish in their fourth year.† and from our knowledge of trade terms and age, the following statistics supplied by the Department of Agriculture and Technical Instruction for Ireland, for the herrings branded at Ardglass during the summer fishery emphasise this importance :—

		Barrels.			
Year.	Large Fulls.	Fulls.	Matties.	Spents.	Total.
1911	35	2,961	1,818 (38%)	—	4,814
1912	—	4,205	6,688 (61%)	—	10,893
1913	5	2,671	5,731 (67%)	133	8,540
1914	—	117	862 (88%)	—	979
1920	—	483	74 (13%)	26	583

* Report, New Series IX., page 43.

† Page 29 of this Report.

Some of the young herrings join the commercial shoals in their third year, but there is little evidence that fish of this age are ever present in sufficient numbers to make any considerable difference in the catches landed. Although some thousands of herrings have been examined from waters about the west, north-west and east coasts of Ireland, Stornoway, the Shetlands, north and east of Scotland and south to Yarmouth, very few herrings with ten winter rings have been found in the samples, and the number with nine winter rings has not been great. For a period of six years the herrings arising from one spawning are of importance in the catches, and throughout that time their numbers gradually decrease. Norwegian herrings and those found about the Faroes and Iceland are caught in fair numbers at a greater age,* but no sample of British herrings has been examined that showed fish with ten or more winter rings worthy of any consideration from a commercial point of view.

Spawning shoals, autumn and spring, and shoals of full herrings off Yarmouth contain more of the older fish than do the summer feeding shoals. But these shoals are added to yearly, and their numbers are increased by additions from the summer feeding shoals of developing herrings which are, most of them, in their fourth year.

It is hardly possible to exaggerate the importance of herrings in their fourth year, and the first evidence we shall have of the presence of a good year-class in the fishery will be from the increased catches made from summer feeding shoals.

The term year-class is very convenient, but may be misleading. British herrings spawn in both spring and autumn, but young arising from both these spawnings in the same year cannot be referred to the same year-class. Last year, in October, large shoals spawned off Yarmouth and Lowestoft. When the products of this spawning enter our commercial shoals, in 1925, they will be referred, from age determination by means of the scales, to the 1922 and not the 1921 year-class. For convenience the term year-class will be used, but it is to be understood it refers to the products of a spring spawning together with those from an autumn spawning in the previous year.

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* Pub. de Circ., No. 53.

In order to obtain a knowledge of our herring shoals after war conditions, a scheme of work was drafted in 1919, and samples were examined from Stornoway and the Shetlands, north coast of Scotland and south to Yarmouth. With the help of the Department of Agriculture and Technical Instruction for Ireland it was possible to extend the investigations into Irish waters in the following year. The samples examined have been reported on in previous papers, and from their age composition it is possible to make the following statement.

From the north-west of Ireland, the north of Scotland and the Shetlands, and south to Yarmouth, the year-classes of 1913 and 1914 were good: the 1915 year-class was poor; and the 1916 year-class was fairly good. In other words, the hydrographic conditions over the whole of these waters had been such that they had had the same effect on the herring population.

The catches made in 1920 and 1921 and the comparatively small numbers of the 1917 and 1918 year-class found in the samples from other than summer feeding shoals point to the 1917 and 1918 year-classes being poor.

The age composition of some of the samples examined was as follows:—

		YEAR-CLASS.							
Locality.	Date.	1918.	1917.	1916.	1915.	1914.	1913.	1912.	1911.
Buncrana ...	... 1/2/21	8	29	17	8	20	12	5	1
Stornoway ...	... 10/2/20	—	23	25	12	15	21	2	1
Lerwick ...	... 21/2/20	—	1	15	8	44	25	5	1
Yarmouth ...	... 20/11/20	—	4	30	10	21	17	11	3*

* 2 per cent. 1910 and 1 per cent. 1909 year-classes.

It is clear from the above that the herring fishery depends upon widespread conditions, and a consideration of the 1904 year-class will show that not only are the herring fisheries about the British Isles at times governed by the same conditions, but that the whole of the North Atlantic is involved, and that some local changes may take place.

The 1904 Year-class.—Canadian Waters.—Lea* from an examination of samples from Canadian waters has been able to prove that the herrings of the northern waters of the Gulf of St.

* Report on Age and Growth of the Herrings in Canadian Waters. Canadian Fish. Exped. 1914-15.

Lawrence and about Newfoundland gave a prolific 1904 year-class. In the south of the Gulf of St. Lawrence the year-class of 1903 was of greatest importance.

Northern Waters.—Hjort and Lea* examined many samples from Norwegian waters and from the Faroes and Iceland, and the 1904 year-class was very good.

It would appear that, whatever the conditions were which produced the 1904 year-class, it took as long for them (the time reckoned by the scales of the herring) to make way against the cold current from Davis Strait as it did for them to reach the waters of Northern Europe.

North Sea.—The importance of herrings with three winter rings in summer shoals has been shown already. The 1904 year-class would appear in our east coast fishery in 1907, and if it were as rich as in Norwegian waters the fishery for that year would show a considerable increase. The catches made on the east coast of Scotland in the early summer and great summer and autumn fisheries were as follows in cwts.†

Year.	1904.	1905.	1906.	1907.	1908.	1909.
Early Summer	220,155	210,090	618,578	980,744	507,440	604,262
Gt. Summer and Autumn	2,240,252	1,865,588	1,882,122	2,567,982	2,203,914	1,634,955

The Channel.—Russell‡ gives some interesting data relating to the herring fishery of the Channel. The monthly landings of herrings in the counties of Devon and Cornwall are given on pages 32-35 of Russell's paper for both steam and sailing vessels. As the records for steam vessels are not uniform in that they show a large increase in the use of steam for herring fishing commencing 1910, those from sailing vessels are considered here only. Further, the Channel fishery is carried on chiefly during the winter months, and the total landings for the three months, November, December and January of the following year, have been taken to show the fluctuations in the fishery. The quantities caught, number of landings, and the average quantity landed per vessel for the years 1906 to 1911 were as follows :—

* Pub. de Circ.,No. 53. † Reports, Fishery Board for Scotland.

‡ Report on Log-Book Records relating to Mackerel, Pilchards and Herring kept by fishermen during years 1895-1911. Fish. Invest., Series II., vol. III., No. 1.

Year.	1906.	1907.	1908.	1909.	1910.	1911.
Cwts.	108,829	54,279	42,985	100,368	105,541	63,836
Landings ...	7,894	6,196	7,121	6,707	7,869	6,605
Average ...	14	9	6	15	13	10

Catches made during the summer months were small and irregular, but those for Cornwall during May and June are of interest.

Year.	1906.	1907.	1908.	1909.	1910.	1911.
Cwts.	1,001	3,390	574	202	71	318
Landings ...	428	501	158	126	353	191
Average ...	2·3	6·7	3·6	1·6	0·2	1·7

There was a new year-class of value added to the May and June shoals in 1907, and in 1909 and 1910 the same year-class increased considerably the catches from the winter shoals.

Fortunately Hjort* examined a sample from St. Ives in December, 1909, and the age composition was as follows :—

Year-class.	1907.	1906.	1905.	1904.	1903.	1902.	1901.	1900.
Percentages ...	9	14	29	24	16	5	2	1

This enables us to refer the increased landings from the May and June shoals of 1907 to the 1904 year-class, and points to the summer feeding shoals of the Channel having much the same age composition as those of the North Sea.

The quantities landed from the winter shoals indicate that the 1904 year-class was six years old before it made its appearance in the winter fishery. The age composition of Hjort's sample shows that the 1905 year-class joined the same shoals when five years old, and also points to this year-class being almost as rich as that of 1904. The joining of spawning shoals by comparatively young fish will be referred to later.

North-west of Ireland.—This fishery is of peculiar interest for it yields no evidence of the 1904 year-class being of any importance. It is evident that a very rich year-class has influenced the fishery, and the data given below show how it made its appearance in the summer fishery of 1909 and added considerably to the catches for three years.

* Pub. de Circ., No. 53, page 160.

Year.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
May, June and July	7,500	11,600	32,500	18,400	33,400	41,700	51,600
Summer	16,400	11,900	36,000	19.600	35,3000	44,900	64,500
Total	23,900	23,500	68,500	38,000	68,700	86,600	116,100

1909.	1910.	1911.	1912.	1913.	1914.
102,400	38,300	22,600	7,700	11,200	20,800
159,600	130,000	98,100	22,200	18,400	41,200
262,000	168,300	120,700	29,900	29,600	62,000

The data given have been supplied by the Department of Agriculture and Technical Instruction for Ireland, and are for the ports of Donegal, from Killybegs to Lough Swilly, the minor ports being omitted. The early summer shoals, May, June and July were landed chiefly at Buncrana and Downings Bay. The fishery varies considerably, and is governed to some extent by prices, weather conditions and the number of boats. In the summer fishery totals for 1902 and 1909 to 1911 the February catches are included, and 1912 to 1914 the September and October catches are included. The May to July herrings are a little smaller than those caught in the same waters during the winter months. They are known as matties, and are called virgin fish in the trade.

Last year Mr. G. P. Farran measured and scaled a sample of herrings from this fishery on 8th June at Downings, and the scales were forwarded to me for age determination. The year 1921 was an exceptionally poor year, and the catches made from early summer shoals were so small as to make it impossible to classify the fishery other than a failure: yet the high percentage of fish with three winter rings shows that here, as in other areas considered, fish of this age are of greatest importance in summer shoals. The age composition of the sample was as follows:—

Winter Rings.	2	3	4	5	6	7	8	9	10
Percentages	2	32	16	6	8	16	7	2	1

It is possible therefore from trade descriptions and the data above to account for the greatly increased catches of 1909, and to say they were due to the very rich year-class of 1906.

There are two coincidences in connexion with this year-class which are worthy of note.

It has been shown that for Channel herrings the waters of the Channel were favourable for the hatching and development of young herrings in 1904. A paper by Gough on the distribution and migrations of *Muggiaea atlantica** is of interest. Muggiaea appeared at the entrance of the English Channel early in 1904, and evidently came from the Bay of Biscay. During the year it gradually spread up the Channel, and also drifted northward, crossing the Bristol Channel in July. In August and early September it was found in the Irish Sea, and had extended westward along the south coast of Ireland. By the end of September it had reached Valentia, and in November it was found in the southern part of Galway Bay. The dates and localities of the finding of Muggiaea suggest a current during 1904 moving from the Bay of Biscay towards the south-west of Ireland, and turning along the west coast. If this current continued during 1905 it would arrive off the north-west coast in time to have an effect on the 1906 year-class as it had on the 1905 year-class of the Channel.

Whilst there may have been some connexion between the distribution of Muggiaea and the 1906 year-class, a more probable explanation of its abundance appears to be in some much greater movement of Atlantic waters. In 1905 water of over 37 per mille salinity advanced to the north-east, threw off an area of high salinity, which in August reached the south-west of Ireland, and probably accounted for the high salinities found off the north-west of Scotland and in the North Sea in October and November.†

Loch Fyne.—Loch Fyne is another area which showed no improvement of the fishery arising from a rich 1904 year-class. For some years previous to the time when this year-class should have made its appearance the fishery had yielded very small catches. The statistics available are of interest, and are here given. They are from the Annual Report of the Fishery Board for Scotland, 1920, page 55.

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* Pub. de Circ., No. 29.

† Matthews. The Surface Waters of the North Atlantic Ocean south of 60° N. latitude, Sept., 1904, to Dec., 1905, page 286. North Sea Fish. Invest. Committee, 2nd Report, pt. 1.

Year.	Cwts.	Year.	Cwts.
1900 ...	86,600	1911 ...	16,352
1901 ...	101,909	1912 ...	7,672
1902 ...	92,186	1913 ...	10,696
1903 ...	74,193	1914 ...	3,216
1904 ...	27,394	1915 ...	13,399
1905 ...	16,352	1916 ...	2,576
1906 ...	18,403	1917 ...	899
1907 ...	13,639	1918 ...	5,763
1908 ...	14,245	1919 ...	41,973
1909 ...	12,894	1920 ...	93,982
1910 ...	36,417		

The catches dropped in 1902, but the fishery could not be considered as a failure until 1904. A condition giving low catches has continued until 1920, a period of eighteen years reckoning from the first signs of failure. This period is a lunar period, and may be considered as approximately equal in time to a complete regression of nodes, or to two complete revolutions of perigee. Lunar phenomena and herring catches will be considered later.

Fortunately we are able to refer to the present age composition of the herrings of Loch Fyne which come from the Inverary Fishery District, in which are included the shoals of the Ayrshire coast. Two samples were examined this year and came from Maidens Bay, Ayrshire coast, and the Ballantrae Bank. They were chiefly fish of the 1917 year-class, and the age composition of the samples was as follows :—

WINTER RINGS.

Locality.	Date.	3	4	5	6	7	8
Maidens Bay	9/2/22	5	12	78	5	—	1
Ballantrae	2/3/22	1	7	87	5	+	—

The last winter ring was taken as coinciding with the edge of the scale.

A comparison of the Loch Fyne fishery with that of the north-west of Ireland yields some points of interest. The herrings differ from those of the north-west of Ireland, having a less rapid growth, and being therefore smaller fish age for age. Growth data will be found on page 35, and can be compared with similar data for Irish shoals given in the last Report. There is also a significant difference in the age composition. The 1917 year-class has yielded the bulk of the Loch Fyne herrings, whilst the 1916 year-class is one of the richest of the younger year-classes from the north-

west of Ireland fishery. A parallel to this is seen in the catches made from the two fisheries in 1909 and 1910. The first of these years gave an enormous increase in the yield from the shoals of the north-west of Ireland, and it was not until the following year that increased catches came from the Loch Fyne shoals.

It would appear that, during the period of the failure of the Loch Fyne fishery, the conditions which determined good or poor year-classes, and which were present in the Atlantic, did not obtain to anything approaching the same extent in the Firth of Clyde, and that these conditions did not reach the Clyde area until a year later than they were off the north-west of Ireland. In other words, the failure of the Loch Fyne fishery has been due to a change in oceanic circulation.

West of the Shetlands.—It has been shown that the North Sea, from the catches of 1907, contained very large numbers of the 1904 year-class. At this time the fishery of the west of the Shetlands was a failure. Some valuable data with regard to the Shetland fishery are given in the Report of the Committee appointed by the Fishery Board for Scotland to enquire into the Scottish whaling industry. The Committee received much evidence which emphasised the fact that the failure of the herring fishery of the west of the Shetlands coincided with the establishment of whaling stations on that coast. The opinion of large numbers of practical men cannot be considered lightly, but it may be that the failure was due, to some extent, to the same causes which brought about the failure of the Loch Fyne fishery.

From the data given in the Report above mentioned (page 13) the most important of the west side sections were Ronasvoe and Hillswick. The catches made at these stations were :—

1903 ...	20,234 crans.	1906 ...	1,406 crans.
1904 ...	41,525 ,,	1907 ...	4 ,,
1905 ...	8,785 ,,	1908 ...	5,642 ,,

The fishery failed in 1905, which was shortly after the failure of the Loch Fyne fishery, and this season, 1922, large catches have been made to the west of the Shetlands. A sample examined in June of this year showed the predominant year-class to be that of 1917, the same as was found in the shoals of the Clyde. The age composition of the sample was as follows :—

WINTER RINGS.

Winter Rings.	2	3	4	5	6	7	8	9	10
Percentages ...	1	6	16	52	9	5	5	4	2

A further sample taken in the first week of July gave a much different age composition, and consisted of mixed fish, recovering spents, developing herrings and virgins. The growth varied considerably, from fish with an oceanic growth to those with a very slow growth. This sample indicated that the recovery of the fishery was due to migrations.

One of the chief difficulties in considering a fishery like that of the west of the Shetlands is the origin of the larval herrings which drift towards the coast. Spawning grounds we know exist between Lewis and the Shetlands, and it would require little change in the direction of drift for the young fish to miss the west coast of the islands.

The Wash.—An example of the effect of drift on the distribution of young herrings is afforded by the Wash. Mr. Donnison, Inspector, Eastern Sea Fisheries District, in reply to a query about sprats and young herrings in the Wash in May, 1920, wrote as follows :—" Sprats and young herrings have practically missed this district for some years. I have known 100 tons to be brought to Boston on one tide. The fishing gradually fell off until the men did not care to fit out for it."

It is considered that sufficient evidence has been produced to show that the conditions which govern the herring fishery are widespread, and may extend over the whole of the North Atlantic, and also that in some periods what may be considered as minor fluctuations in oceanic circulation bring about local changes.

Migrations.—We know little of the migrations of the herring, and the following is written with the idea of showing the probability of increasing our knowledge by a consideration of statistics and trade descriptions relating to catches.

In the early months of the year, January to March, catches are made from shoals of spring spawning fish from the north-west of Ireland, about the north of Scotland, including the Shetlands and Orkneys, and in the Firth of Forth. This fishery is followed in April by a fishery for spent herrings which, in the North Sea, are caught by drifter liners for the purpose of bait, practically

anywhere from the Shetlands to Bergen Bank, and from North Shields to the Naze. In the southern part of the North Sea the spent herrings give the spring fishery from Yarmouth and Lowestoft. Early in May young summer fish are caught in the bait catches, and as the month advances the number of drifter liners gradually decreases, and herrings are sought nearer the chief fishing ports. Data have been given* which point to the young herrings moving shoreward from deeper water. On the Northumberland coast shoals of young developing fish may yield in some years the chief part of the catches as early as the middle of May, but as a rule it is not until the beginning of July that the huge shoals of young fish appear off the coast. During May and June the catches contain large numbers of recovering spents, and these, together with the May, June and early July shoals fished off the north-west of Ireland, west of Barra, west of the Shetlands and Orkneys, and the mid-summer fishery from Yarmouth and Lowestoft point to the spring spawners shoaling when recovering from spawning. Few samples from these peculiar May, June and early July shoals have been examined, but the data given on page 30 for the north-west of Ireland, west of the Shetlands, as well as the sample from Yarmouth in June, 1921, indicate that the recovering spents frequent summer fishing grounds until the early part of July. During this time, it appears from the Yarmouth samples that the herrings gradually improve in quality, the gonads recovering and a store of fat accumulating in the body cavity.

After the beginning of July our herring fishery of the east coast depends entirely upon the shoals of young developing fish, and all trace of recovered spents is lost except for small numbers found in the samples. In August the grounds are invaded by shoals of larger and older herrings, and these, together with those of the young herrings sufficiently developed, form the autumn spawning shoals. The spent fish quickly disperse, leaving on the grounds small shoals of young herrings which have taken no part in the spawning. These in their turn, by about the middle of September, disappear; they are unable to yield a fishery productive enough to keep the fishing vessels in the district. From the inspection of many herrings in the curing houses of North

* Report, New Series VIII., page 28.

Shields in November and December, it would appear that the shoals landed at Mallaig indicate a shoaling of recovering spents from autumn spawners for the grounds of the west coast of Scotland. These grounds are frequented at this time of the year chiefly by full fish about to become spring spawners. No data of a similar nature have been obtained for the North Sea.

In September herrings are trawled in the vicinity of the Dogger Bank, and during the past two years large quantities have been caught on the Fladden Grounds. In a previous report* the opinion was expressed that the trawled herrings landed at North Shields were autumn spawners, but more complete observations and increased experience have convinced the writer that this is not a full statement. Spawning fish and spents occur amongst the trawled herrings, and in some catches they predominate, but many of the trawled herrings landed at North Shields in September and October are undoubtedly not autumn spawners. They are firm fish, and the state of the gonads points to their being the forerunners of the herrings which give the East Anglian herring harvest in October and November. Not many catches have been seen from the Fladden Grounds, but those observed have proved to be very like the catches made in the vicinity of the Dogger Bank. From this it appears that the grounds fished by trawlers are frequented not only by autumn spawners but also by immense numbers of spring spawners which have congregated there after their disappearance in the early part of July.

During the same month, September, shoals of autumn spawners are fished off Whitby and Scarborough. On the grounds off Grimsby and about the south-western end of the Dogger large catches are made by our vessels and Dutch luggers. What the state of development of these fish is cannot be stated definitely, but from observations made on trawled herrings and the description of the herrings obtained from fishermen and curers it would appear that most of these herrings are spring spawners with the gonads far enough developed to be classified as full fish.

The fishery from Yarmouth and Lowestoft in October and November is one mainly for full fish which are without doubt spring spawners. Samples from spawning shoals can be obtained

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* Report, New Series IX.; page 35.

and spent herrings may be observed in the catches, but the observations made in the curing houses at North Shields leave no doubt as to the nature of the bulk of the fish caught. At this time the herrings have their gonads nearly fully developed, they are firm fish, and nearly ready for the act of reproduction. They are in the best condition, and it is this fact which accounts for the excellency of the East Anglian herring. The herrings disappear from the southern waters in early December. No sample of spring spawners has been examined which has given growth data comparable with that of the East Anglian shoals, and the location of these shoals after early December is a matter of conjecture. That some of the November herrings return to Yarmouth waters in March as spent fish and remain there until June is evident from the data given on page 24.

When reporting on the samples examined in 1913 * it was shown that the growth increment of the year of capture showed a change in the composition of the herrings of the Northumberland coast in early September. In a later report† a consideration of the first year growth led to the conclusion that our local grounds received additions throughout the season. The extended sampling undertaken during 1919‡ yielded data which pointed to other grounds receiving waves of immigrants during the progress of the fishery.

It was considered that if the evidence yielded by growth data had been read correctly the waves of immigrants would have shown an appreciable difference in the catches landed, and to test this the data in Table I. have been tabulated. The data relating to North Shields landings have been obtained from the officials of the Ministry of Agriculture and Fisheries at North Shields; Mr. Beazor, of Yarmouth, has supplied me with particulars of the fishery of that port obtained from the Harbour Commissioners; Dr. J. Metzeelaar, of Bloemendaal, Holland, has sent me the catches and fishing grounds of Dutch luggers: and the data relating to the Scarborough and Grimsby fisheries have been obtained from the Ministry of Agriculture and Fisheries. These data have been

* Report, New Series III., page 63.
† Report, New Series VIII, page 37.
‡ Report, New Series IX., pp. 25-26.

arranged to show for each week the number of catches made, the total catches, and the average catch. In connexion with the catches made by Dutch luggers the fishing grounds are given; these are referred to by letters and numbers, and the corresponding latitude and longitude are given.

For North Shields, data are given for three years. At the beginning of the season, which is taken as commencing when drifters depend solely upon the herrings caught, the bulk of the catches are taken from 50 to 100 miles from the port. Catches decrease until towards the end of May, when they increase, and this change is accompanied by a change in the fishing grounds; the vessels now fish from 12 to 30 miles from the port.

The data given for 1919 show increased catches towards the end of May at a time which coincided with a change of fishing grounds to waters nearer the coast. During June the catches decreased, and it was not until the beginning of July that the fishery improved. The sudden change which then took place is taken as being due to a wave of migrants coming into the district. These migrants may have remained in Northumberland waters, or they may have moved to other grounds, but it is quite clear that they were not present in sufficient numbers to keep the fishery at a high standard during the middle of July. Towards the end of July the catches increased, and the improvement gradually continued until the middle of August, in which month, in the last week, there was a sudden fall in catches. This was followed by an increase in the first week of September, and then a decrease until the vessels landing at North Shields commenced to fish the grounds off Whitby and Scarborough.

The years 1920 and 1921 show, practically, the same changes in the catches made throughout the season. There are differences but the data given show that the fishery depends upon waves of migrants coming into the district. The May migrants of 1920 were about a week later than those of 1919, and in 1921 their numbers were insignificant. In July of both years the shoals were a fortnight later than in 1919, and lateness seems to have marked the migrations which gave the August and September catches. In 1921 vessels were fishing the Whitby and Scarborough grounds as early as 31st August, and in the first week of September these were the chief grounds fished.

From a consideration of first year growth the changes in the herrings on our fishing grounds off Northumberland have been stated to be as follows.* Herrings with a comparatively small first year growth appeared on the grounds in the latter part of June and early July. Towards the end of July and in August fish with a comparatively large first year growth were more abundant, and in September the samples have been marked by the number of fish with a comparatively small first year growth.

These changes in the shoals coincide with the catches made and the data here given suggest the possibility of timing the arrival of the herrings on the grounds.

The close agreement between catches and movements of herrings to the Northumberland grounds as determined from growth data, and changes in growth data observed in other shoals during the season,† suggested the possibility of comparing the North Shields catches with those made from other ports.

The catches landed in 1920 at North Shields, Scarborough, Grimsby and Great Yarmouth, as well as those made by Dutch luggers, are shown graphically in Figure I.

It will be observed that during July, August and September there is considerable agreement between the curves representing the North Shields catches (Northumberland coast) and those made by Dutch luggers in the vicinity of the Dogger Bank. Both curves show rises and falls in the catches, separated by the same intervals of time, but the highest catches made in the vicinity of the Dogger Bank are a week later than those made in Northumberland waters.

After 25th September the North Shields catches were made chiefly off Whitby and Scarborough.

The rise in catches made by Dutch luggers for the week ending 25th September is followed a week later by an enormous increase in the catches made by vessels fishing out of Grimsby, and to a less extent by those made by Scarborough vessels.

When the increase took place in September the Dutch luggers were fishing in an area bounded by 54° to 55° N., 1° to 2° E., and the Grimsby vessels in 53° 30′ to 54° N., 0° 30′ to 1° 30′ E. The

* Reports, New Series VII. and IX., pp. 37, 25-31.
† Report, New Series IX., pp. 25-26.

Scarborough vessels were fishing close to the coast in the vicinity of that port.

Whilst the difference of a week in the catches made off the Northumberland coast and in the vicinity of the Dogger Bank cannot be taken as referring to migrations of the same shoal of herrings, the nearness of the grounds fished by Dutch luggers and Grimsby vessels suggests the idea that the herrings were moving in a south-westerly direction. This idea is strengthened by the first signs of increased catches appearing in the north-east portion of the area fished by Dutch luggers in the week ending 18th September. The average number of barrels caught in the different portions of the area was as follows :—

Week ending September	4th.	11th.	18th.	25th.	30th.
54° 30′ to 55° N., 1° 30′ to 2° E. ...	0	8	32	24	42
54° 30′ to 55° N., 1° to 1° 30′ E. ...	10	18	4	22	23
54° to 54° 30′ N., 1° 30′ to 2° E. ...	7	8	20	28	15
54° to 54° 30′ N., 1° to 1° 30′ E. ...	14	15	16	41	36
Grimsby Grounds (cwts.)	86	74	76	71	202

Further evidence of a south-westerly movement of the herrings is afforded by the catches of spent fish made by Dutch luggers, and the value of this evidence is increased by the fact that no spent fish appeared in the catches previous to the first catch of spawning or "running" fish on the grounds. The first of the spawning fish were noticed on 7th September, but it was not until the 15th that any quantity was caught. The quantities of spent fish were not great until 21st September, and the first recorded for the grounds were caught on the 8th. Spawning took place in an area bounded by 54° 22′ to 55° 5′ N., 1° to 1° 50′ E., but chiefly in 54 40′ to 55° 5′ N., 1 30′ to 1 50′ E. Spent fish were caught practically all over the grounds. The south-westerly migration of spents is best seen in the early period when spawning fish and spents appeared, up to 23rd September, and if the region fished and catches made be arranged as below the migration is apparent.

	AREAS.				
	N.E.	N.W.	S.E.	S.W.	
Catches of spawning fish	208½	2	—	—	barrels
Catches of spent fish	—	18	13	43	„

The spawning grounds were in the upper portion of the north-east area. The spents taken in the north-west area were caught

near its southern limits, and those in the south-east area near its western limits.

In the week ending 9th October one or two of the Dutch luggers were sampling the fishery on the grounds off Yarmouth, and in the week following the Dutch vessels, for which records are to hand, had all moved south. The highest catches in the season were made in the week ending 30th October, and in the same week the Yarmouth vessels took their greatest catches. But whilst the catches made by Dutch luggers were considerably smaller in the following week, no such feature marked the catches made by the Yarmouth vessels. As a result of many inquiries made of fishermen and merchants, there is no doubt that, whilst Dutch and British vessels may fish close together, there is a decided tendency for the Dutch luggers to fish in more easterly waters than do the British vessels. If this be the case then the catches made by British vessels point to the shoals off Yarmouth moving in a westerly direction.

The data for catches made by Yarmouth vessels for the three years, 1919-1921, indicate the immigration of waves of herring shoals into the waters fished. In the early part of September many of the vessels landing at Yarmouth have caught their fish on Grimsby grounds, and a more detailed knowledge of catches from different grounds is necessary. A peculiar feature in the Yarmouth catches is the lateness of the season of 1921. It was a fortnight later than the two previous seasons.

Attention has been drawn to the July shoals off the Northumberland coast being a fortnight later in 1920 and 1921. The years 1920 and 1921 were marked by abnormal activity of Atlantic waters. In the first year of this activity the Northumberland July shoals were a fortnight late, but no difference in time marked the Yarmouth shoals. In the second year not only were the July shoals a fortnight late, but the arrival of the shoals fished from Yarmouth were postponed for the same interval of time. The significance of this will probably be more apparent when hydrographic data for the years under consideration are available.

Fluctuations.—The finding of reliable statistics for a long period is one of the greatest difficulties when considering the fluctuations in the herring fishery, and the difficulty is increased by the

fact that few hydrographic data are available for years previous to 1904.

A comparison of catches with salinity data was begun, and the data available for the English Channel, which have been reported on by Dr. E. C. Jee,* were used. The period covered is considered much too short. Except for a possible connexion between a high salinity early in the year, followed by a gradual decrease during the year of hatching, and a subsequent good year-class, nothing was found worthy of note.

Owing to the war it was not until some time towards the end of 1920 that Professor D'Arcy Thompson's paper on "Mean Sea Level and its Fluctuations" † came to my notice. The range of tide, or interval between mean high and mean low water, for Aberdeen suggested a possible connexion between hydrographic conditions, as indicated by tidal phenomena, and herring catches. The mean monthly values, in feet, for this range for the period 1862 to 1913 were as follows :—

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
9·01	9·14	9·25	9·27	9·12	9·04	9·12	9·34	9·40	9·25	9·01	8·86

Maxima occur in March-April and August-September, and they coincide, practically, with the two chief spawning times, spring and autumn.

The only data available which gave an indication of the productivity of the fisheries over so long a period were the quantities of herrings cured in Scotland.‡

The nineteen-year period found by Professor Thompson for mean annual inter-tidal range at Aberdeen gave a curve which suggested a further relation between tidal phenomena and good years in the East Coast fishery, and a smoothing of the yearly herring cure of the East Coast in groups of three and five years hinted at the possibility of there being two maxima for herring catches in a nineteen-year period, one coming after the maximum for tidal range and the other following the minimum. In this connexion the herrings cured were dealt with from 1816, and the nineteen year period was assumed to hold good for the years previous

* Bd. of Agric. and Fish. Fish. Invest., Series III. Hydrography.
† Fisheries, Scotland. Sci. Invest., 1914, IV.
‡ Fishery Bd. for Scot. Annual Report, 1920, pp. 128-131.

to 1862. The gradual increase in quantities cured due to improved fishing vessels * had to be considered also.

Plotting out the monthly values for range of tide showed considerable differences throughout the period, and to obtain data in a form considered suitable for the purpose, the differences between the spring and autumn maxima and the summer and winter minima have been found and summed for each year. These are given in Table II.

It has been stated before when reporting on herring investigations that it was not considered the hydrographic conditions obtaining during the year of capture were the chief factor which determined the productivity of the fishery, and the opinion has been expressed that the conditions at the time of hatching were of greatest importance. This and the fact that the east coast fishery of Scotland depends chiefly upon the abundance of fish with three winter rings on their scales determined a comparison between tidal data and the catches made three years later. The result was not satisfactory.

The samples from spring spawning shoals in 1921, following the abnormal activity of Atlantic waters in 1920, showed for the Firth of Forth and Broad Bay† what was considered to be an abnormal number of spawning herrings at the end of the third growth period. The sample from the north coast of Sutherlandshire in the same year contained also what was considered a high number of herrings of this age. Further sampling in the spring of 1922 has made it quite clear that the high numbers of these young fish were not due to accidental sampling. The occurrences of these young fish in what is considered to be abnormal numbers, and the fact that in 1903, a year in which Matthews ‡ considered conditions abnormal over the larger part of the northern European area, Fulton § found cod spawning in autumn in the North Sea suggested a new working hypothesis when considering fluctuations in catches and hydrographic data. This hypothesis is that the conditions preceding the year of spawning are of greatest

* See "Post-war Problems," Lieut.-Commander D. T. Jones, R.N.R. Fish. Bd. for Scot., Annual Report, 1918, page 3.

† Report, New Series X., page 90.

‡ Report on the Physical Conditions of the English Channel and adjacent waters, 1904 and 1905, page 293. North Sea Invest. Committee, 2nd Report, Southern area, Cd. 4641.

§ Pub. de Circ., No. 8.

importance in producing good year-classes. As there is a period of three years between the time of hatching and the joining of the commercial shoals in any great numbers doubtless other factors have their influence, but as they are thought to be of secondary importance they have not been considered yet to any extent.

Figure II. shows graphically the number of barrels of herrings cured on the east coast of Scotland from 1862 to 1913, and the yearly values of the sum of the differences between spring and autumn maxima and summer and winter minima of tidal range as given in Table II. A difference of four years between tidal data and herrings cured is taken.

It will be observed that for a period of twelve years, from 1867 to 1879 for herrings cured and from 1863 to 1875 for tidal data, the curves tend to run parallel. The greatest values for tidal data correspond with the greatest quantities of herrings cured, and the lowest points in the tidal curve are above similar points in the curve for herrings cured. For the following six years, 1879 to 1885, the curves are opposite in value, and the highest points for tidal data correspond with the lowest quantities of herrings cured and *vice versa*. From 1885 to 1891 (herrings cured) there is another period of six years in which the curves tend to be parallel, and this is followed by a six-year period in which the curves show practically the same as for the period 1879 to 1885. The period 1897 to 1908 (herrings cured) can be taken as showing a general parallelism between herrings and tidal data, and that from 1908 to 1914 as having tidal data of highest value when the herring cure is at its lowest.

From 1896 the actual herring catches for the east coast of Scotland are represented by the dotted line, and these emphasise the parallelism or convergency of the curves.

In the two longer periods, 1867 to 1879 and 1897 to 1908, there is a tendency to change shown in the years 1873 and 1902 respectively. There is also a doubt as to whether the year 1897 or 1898 should be taken as the year of change. It is quite clear, however, that there is a periodicity in the relation between tidal activity and herring catches, and that the periods can be taken as approaching six and eighteen years in duration. Larger periods may exist and are suggested by the low values for tidal data coinciding with the comparatively small numbers of herrings

cured in 1888 to 1891, but the increase in the catching power of fishing vessels makes comparison difficult.

The comparatively high values for tidal data in the years 1912 and 1913 would be followed by the year-classes of 1913 and 1914, and these have been shown to be the most important amongst the older year-classes of our shoals.

An interesting point with regard to this relation between tidal data and herring catches is that Helland-Hansen and Nansen found, for the years 1901 to 1905, there was a relation between the extent of coastal water and the sprat fishery, whilst Lea continuing the investigations, 1910 to 1912, found that this relation no longer held. Helland-Hansen and Nansen found the curves representing the coastal water area and sprat catches tended to run parallel, and Lea that the high sprat catches of 1911 coincided with the small extent of coastal water in that year.*

The periodicity shown above and the finding of two maxima for herrings in the nineteen-year period, found by Professor Thompson for intertidal range, have indicated the possibility of a lunar period of nine years occurring in our herring fishery.

The quantities of herrings cured on the east and west coast of Scotland have been arranged in nine-year periods in Table III. for the years 1815 to 1920, and the totals for each year of the period from 1824 to 1913 are shown graphically in Figure III. Data for Yarmouth catches, supplied by Mr. Beazor, are similarly dealt with from 1869.

It is possible if in any year herrings are found to be plentiful on one coast of Scotland and less abundant on the other that a concentration of fishing vessels will intensify the difference in catches, and also the gradual improvement in the catching power of fishing vessels may tend to make the totals for the later years of the period have a high value.

The curves show some interesting points of agreement and difference. In all cases year number 3 is marked by high catches. For years number 6, 7 and 8 the west coast curve shows a poor fishery, whilst for the same years for the east coast high catches are indicated. The Yarmouth catches show a gradual increase in catches during years 7, 8 and 9.

* Hjort. Fluctuations in the Great Fisheries of Northern Europe. Report and Proc. Verb., vol., xx., page 191.

O. Pettersson in a paper "Long Periodical Variations of the Tide Generating Force" * has shown that the moon and sun have considerable influence on the waters of the earth, and that the tide generating force varies through a nine-year period. This tide generating force which produces activity in Atlantic waters was at its highest at intervals of nine years from and before 1903.† It coincides with year number 8 in this paper, and is followed by an interval of four years by the increased catches of year number 3. This is taken as indicating that the activity of Atlantic waters has an effect on the production of a good year-class, and together with the fact that herrings with three winter rings have been found to be of such great importance in the fishery, it gives support to the working hypothesis that the conditions preceding the year of spawning are of greatest importance in determining a good year-class.

The difference between the east and west coast fisheries for years number 6 to 8 is taken as indicating the possibility of northern waters having some effect on the east coast fishery by bringing about variations in the flow of Atlantic water into the North Sea. In this connexion it is of interest to recall the following statement by Matthews.‡ "It may be accepted as an axiom that for the purpose of fishery investigations it is not so much the mean hydrographic conditions as the deviations from this mean which are of primary importance, and this holds with special force in the areas of which the fish fauna is fairly well-known." An abnormal inflow of northern waters into the northern North Sea does not appear of itself to be sufficient to produce a good year-class, for the year 1908, when cold water reached as far south as Aberdeen,§ was not followed by any indications of a year-class worthy of note in the herring fishery of the East Coast of Scotland. The best herring season since 1907 was that of 1910, and after that the catches gradually decreased. The 1910 catches were due probably to the extensive salt water inflow stated by Robertson‖ to have taken place into the North Sea throughout the winter of 1905-6, and

* Pub. de Circ., No. 65.

† O. Pettersson. "Climatic variations in historic and prehistoric times."

‡ Report on the Physical Conditions in the English Channel and Adjacent Waters, 1906, page 271. North Sea Fish. Invest. Committee, 3rd Report, Southern Area, Cd. 5546.

§ Robertson. Report on Hydrographic Investigations in the North Sea and Faroe-Shetland Channel during the years 1907-1908. North Sea Fish Invest. Committee, 4th Report, Northern Area, Cd. 4893.

‖ Op. cit., pp. 163-164.

brought about by the abnormal conditions existing in the Northern Atlantic.

The Yarmouth fishery differs from that of the east coast of Scotland and also from that part of the west coast fishery which has been sampled from Stornoway. The Yarmouth shoals consist of older herrings, and it is possible that other factors may bring about the increased catches of years number 7 to 9. In these years the tide generating force is at its highest, and Atlantic water reaches its greatest activity. It has been shown by Pettersson* that the herring fishery of the Baltic has fluctuated with the activity of Atlantic water as influenced by the position of the moon. The herrings penetrate into the Baltic according to the inflow of Atlantic water, and it is possible that large inflows of water of high salinity would drive or carry the herrings into the southern waters of the North Sea and be the chief cause of big catches, provided always the herring population was large enough for the purpose.

The increased catching power of fishing vessels has been referred to. This makes the reading of the Yarmouth data more difficult, especially for the years 1904 to 1913. From the catches made during the periods 1878 to 1886 and 1887 to 1895 it would appear that migrations, if migrations be the cause of the large catches in years number 7 to 9, are not so great during each period, and that the greatest movements of fish into the southern North Sea are separated by a period of eighteen years.

A periodicity in migrations is suggested by the catches of winter herrings on the east coast of Scotland. For a number of years the catches from the winter fishery were small, and then came an increase. The maximum catches were made in the years 1902 to 1905, and since then there has been a general tendency to lower catches. This is shown by the following data supplied by the Fishery Board for Scotland.

Year.	Cwts.	Year.	Cwts.
1896 ...	70,499	1905 ...	237,575
1897 ...	65,853	1906 ...	190,551
1898 ...	75,009	1907 ...	224,880
1899 ...	112,174	1908 ...	170,065
1900 ...	190,875	1909 ...	65,681
1901 ...	177,281	1910 ...	82,109
1902 ...	276,682	1911 ...	78,509
1903 ...	220,799	1912 ...	88,150
1904 ...	276,195	1913 ...	96,118

* Climatic variations in historic and prehistoric times.

From various of the Annual Reports of the Fishery Board for Scotland it is clear that a period when the winter fishery of the east coast was highly productive occurred previous to 1896. During the last two months of 1885 large shoals of herrings were discovered where they had never been seen before. They were especially abundant off the Aberdeenshire coast, and in the Moray Firth and northward to the Pentland Firth they were in greater abundance than in any former winter. In the Annual Report for 1886 attention was drawn to the winter fishery, during the last two years, becoming an important industry nearly all along the east coast from the Firth of Forth to the Pentland, and during January to the end of March immense shoals of herrings were found along the coast, lying generally from one to six miles off-shore. This fishery was highly successful in 1887, and in 1888 not so productive as in the two preceding years, whilst in 1889 the fishery was still worse. From the fact that the herrings increased in size from 850 to the cran in 1887, 780 to the cran in 1888, and 700 to 780 to the cran in 1889, there does not appear to have been any additions of young fish to the shoals, and it is possible the appearance off the east coast of such huge shoals was due to a migration in 1885. The size of the fish was great, and more in keeping with that of oceanic herrings than North Sea fish. The year 1885, reckoning the nine-year period from 1903, would coincide with the year of greatest tide generating force, and the interval between the herring catches of the eighties and those of 1902 to 1905 is approximately an eighteen year period, the same as Pettersson found for the Baltic fishery. There is this difference, that whilst the east coast maxima occur about 1885 and 1904, the Baltic fishery then shows minima.* The high catches in Yarmouth waters in 1884 to 1886 further emphasise the difference between the North Sea and the Baltic, and point to a periodic movement of shoals which benefits every nine years the British and Baltic fisheries alternately. If this alternation of periods holds good, our East Anglian fishery should have received the benefit of it during the past two years, and should benefit this coming season.

The catches which have been made this year to the west of the Shetlands are probably also due in part to a migration which

* Pettersson. Climatic variations in historic and prehistoric times page 21.

has coincided with Atlantic water activity. Whilst the high number of herrings of the 1917 year-class in the June sample of this year indicates a change in the drift of larval herrings, another sample examined in early July points to other factors influencing the fishery. The mixed nature of the sample as regards development of gonads and growth (page 66) points to the shoal from which it was taken as having a composition which could be brought about by migrations only.

One of the striking things in connexion with our herring fisheries of 1920 and 1921 was the poor quality of the herrings, and Mr. Beazor, of Yarmouth, informs me that in the whole of his twenty-six years' experience he has not known herrings so bad as they were in 1921. He emphasised also the difference, to which attention has been drawn on page 23, between the Clyde herrings and those of the North Sea, and stated that during last season Clyde herrings were brought to Yarmouth and there cured. That this difference between the Clyde and the North Sea was so marked denotes probably a difference in time or intensity of the flow of Atlantic water into the Clyde area, as the poor quality of North Sea herrings coincided with an abnormal invasion of Atlantic water into the North Sea.

It has not been possible to obtain any data relating to the quality of herrings over a number of years, but Hjort* gives some facts in connection with the condition of Norwegian cod. It was found that the quantity of liver obtained from Lofoten skrei (large cod) varied considerably from year to year, and a comparison was made with the number of sun spots to see if there was an agreement between the two phenomena. Now, the sun-spot period during the years under consideration was approximately a thirteen-year period, and no relation between the two curves is apparent. But if the cusps of the liver curve be considered they will be found to fall in the years 1890, 1899 and 1908, showing clearly a nine-year period. The years for the least amount of liver do not fall so regularly, but they tend to come midway between the maxima and to follow what have been stated to be years when the tide generating force of the moon approaches a maximum.

* Fluctuations in the Great Fisheries of Northern Europe.

Hjort has stated the opinion and supplied data to support it, that the great fluctuations which take place in the quantity of liver from year to year are due chiefly to variations in the composition in point of age and size, not in the quality of the fish. Now if this be the case, seeing that the greatest quantities of liver were obtained in 1890, 1899 and 1908, it is the same as stating that large cod tend to occur in nine-year periods.

The following statistics for catches of cod for Nordland are taken from the Report of the Committee appointed by the Fishery Board for Scotland to enquire into the Scottish whaling industry, page 15.

Year.	Thousands.	Year.	Thousands.
1898 ...	16,897	1907 ...	20,906
1899 ...	17,401	1908 ...	16,974
1900 ...	10,796	1909 ...	19,874
1901 ...	15,491	1910 ...	17,278
1902 ...	17,959	1911 . .	15,120
1903 ...	19,441	1912 ...	24,602
1904 ...	18,598	1913 ...	15,951
1905 ...	16,831	1914 ...	19,306
1906 ...	22,321	1915 ...	23,590

From the catches of 1903, 1906 and 1907, 1912 and 1915 it is clear that if the large fish are predominant in certain years and give large yields of liver, governed by a nine-year period, in other years small cod come on to the grounds in considerable numbers. Great quantities of liver were obtained in 1908, and the next nine-year period would give 1917 as the year of greatest liver yield, therefore 1903 and 1912 were the years when young cod joined the shoals in greatest numbers. Hjort states that in certain years (1903) greater numbers of young fish may be present. These years, 1903 and 1912, were years of great activity of Atlantic waters, and according to the above data they are marked by large numbers of young cod amongst Norwegian shoals of adult cod. The activity of Atlantic water in 1920 was followed by what is considered a high number of young herrings in our spring spawning shoals, and the activities of the year 1921 coincided with the poor condition of North Sea herrings. It is possible that the chief cause of the fluctuations in the yield of liver from Norwegian cod is to be found in periodic changes in the flow of Atlantic waters, which tend to drive young fish into the shoals and lower the conditions of the older fish.

The year 1903 was followed by the year-class of 1904, which in 1913 gave 50 per cent.* of the cod examined by the Norwegians. The same year-class for herrings was the mainstay of the Norwegian fishery for a number of years, and gave the large catches of 1907 on the east coast of Scotland. The activity of Atlantic waters in 1912 was followed by the year-classes of 1913 and 1914 in our herring fisheries. It would appear that the year 1921 will be followed by a good year-class of 1922. Fish from this year-class should make their appearance in our herring fisheries in 1925.

It is possible, however, that the comparative value of the fishery of 1925 may be influenced by the number of young fish which spawned in the spring of 1921, and by hydrographic conditions which may occur in 1924 and drive young herrings into the spring spawning shoals of 1925 before they enter the summer shoals. The latter would lower the summer catches, just as in 1921 it intensified the failure of the fishery.

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* Hjort. Op. cit., page 159.

TABLE I.

HERRING CATCHES.—NORTH SHIELDS (Drift Net).

1919.				1920.				1921.			
Week ending.	Landings.	Crans.	Average	Week ending.	Landings.	Crans.	Average.	Week ending.	Landings.	Crans.	Average.
10th May ...	2	26	13·0	8th May ...	12	90	7·5	7th May ...	7	31	4·4
17th May ...	3	19½	6·5	15th May ...	59	205	3·5	14th May ...	44	199	4·5
24th May ...	71	630	8·9	22nd May ...	62	194	3·1	21st May ...	65	123	1·9
31st May... ...	191	1534	8·0	29th May ...	108	1086	10·0	28th May ...	62	121	2·0
7th June ...	382	1211	3·2	5th June ...	206	1063	5·1	4th June ...	116	212	1·8
14th June ...	374	873	2·3	12th June ...	229	784	3·4	11th June ...	144	93	0·6
21st June ...	383	506	1·3	19th June ...	—	—	— *	18th June ...	213	338	1·6
28th June ...	285	707	2·5	26th June ...	362	1345	3·7	25th June ...	285	564	2·0
5th July	328	6082	18·5	3rd July ...	432	1485	3·4	2nd July ...	366	1102	3·0
12th July	704	2970	4·2	10th July ...	401	3556	8·8	9th July ...	433	1551	3·6
19th July ...	418	2377	5·7	17th July ...	237	3952	16·7	16th July ...	514	3668	6·7
26th July ...	597	4784	8·0	24th July ...	315	3548	11·2	23rd July ...	614	1201	1·9
2nd August ...	690	6912	10·0	31st July ...	366	3043	8·3	30th July ...	515	2220	4·3
9th August ...	784	7561	9·6	7th August ...	589	4122	7·0	6th August ...	479	2656	5·6
16th August ...	364	4871	13·4	14th August ...	623	6504	10·4	13th August ...	596	2866	4·8
23rd August ...	514	7234	14·1	21st August ...	642	4587	7·1	20th August ...	536	1814	3·4
30th August ...	506	5323	10·5	28th August ...	656	4642	7·1	27th August ...	532	3749	7·0
6th September ...	487	6464	13·2	4th September	576	5586	9·7	3rd September	264	1454	5·5
13th September	264	2563	9·7	11th September	231	2588	11·2	10th September	110	1262	11·5
20th September	120	1501	12·5	18th September	128	1762	13·8	17th September	90	1327	14·7
27th September	17	555	32·6	25th September	38	106	2·8	24th September	94	973	10·4
2nd October ...	2	134	67·0	2nd October ...	24	665	27·7	1st October ...	86	330	3·8

* Vessels laid up pending Government decision as to price of 50s. per cran being guaranteed.

TABLE I.—(Continued).

HERRING CATCHES.—GREAT YARMOUTH.

1919.				1920.				1921.			
Week ending.	Landings.	Crans.	Average.	Week ending.	Landings.	Crans.	Average.	Week ending.	Landings.	Crans.	Average.
6th September ...	32	2287	71	4th September	60	3185	53	3rd September	14	490	35
13th September	72	3131	43	11th September	130	5069	39	10th September	65	2266	35
20th September	113	9807	87	18th September	86	3740	43	17th September	134	6957	52
27th September	259	9712	37	25th September	272	10,924	40	24th September	153	4263	28
4th October ...	1096	18,986	17	2nd October ...	1175	34,335	29	1st October ...	171	2858	17
11th October ...	1728	42,401	25	9th October ...	2159	48,643	23	8th October ...	751	13,768	18
18th October ...	1991	65,740	33	16th October ...	3140	100,050	32	15th October ...	525	8838	17
25th October ...	2493	86,148	35	23rd October ...	2407	99,590	41	22nd October ...	1834	89,825	49
1st November ...	1557	47,827	31	30th October ...	2137	124,010	58	29th October ...	2286	48,641	21
8th November ...	1969	91,893	47	6th November	1120	64,186	57	5th November ...	2302	45,377	20
15th November	1705	61,550	36	13th November	1693	62,166	37	12th November	1392	28 162	20
22nd November	1017	19,257	19	20th November	803	22,688	28	19th November	2089	79,411	38
29th November	672	14,631	22	27th November	625	30,544	49	26th November	846	17,009	20
6th December ...	285	6563	23	4th December ...	448	13 237	29	3rd December ...	303	8116	27
13th December ...	151	1610	11	11th December	112	700	6	10th December	235	4672	20
								17th December	185	3026	16

TABLE I.—(Continued).

HERRING CATCHES.—DUTCH LUGGERS, 1920.

Week ending.	Catches.	Barrels.	Average.	Chief Fishing Grounds.
10th July ...	2	4	2	
17th July ...	12	80	7	L 31 = 55° 0′—55° 30′ N, 1° 0′—1° 30′ E.
24th July ...	20	256	13	M. 30 = 54° 30′—55° 0′ N., 0° 30—1° 0′ E.
31st July ...	37	183	5	M. 31 = 54° 30—55° 0′ N., 1° 0′—1° 30′ E.
7th August ...	16	144	9	
14th August ...	16	152	10	M 31.
21st August ...	15	208	14	N. 31 = 54° 0′—54° 30′ N., 1° 0′—1° 30′ E.
28th August ...	26	209	8	
4th September ...	36	414	12	M. 31.
11th September	44	623	14	M 32 = 54° 30′—55° 0′ N., 1° 30′—2° 0′ E
18th September	47	940	20	N. 31.
25th September	43	1294	30	N. 32 = 54° 0′—54° 30′ N.. 1° 30′—2° 0′ E,
2nd October ...	33	857	26	M. 32; N. 32.
9th October ...	33	728	22	N. 33 = 54° 0′—54° 30′ N., 2° 0′—2° 30′ E.
16th October ...	26	1310	50	Q. 33 and 34 = 52° 30′—53° 0′ N., 2° 0′—3° 0′ E.
23rd October ...	46	2218	48	R. 33 and 34 = 52° 0′—52° 30′ N., 2° 0′—3° 0′ E.
30th October ...	40	3575	89	
6th November ...	22	703	32	
13th November ...	50	1136	23	Q. 33 and 34.
20th November	39	209	5	R. 33 and 34.
27th November	66	1525	23	

TABLE I.—(Continued).

HERRING CATCHES 1920.—(Drift Net).

	Scarborough.			Grimsby.		
Week ending.	Landings.	Cwts	Average.	Landings.	Cwts.	Average
4th September	160	13,300	83	62	5,311	86
11th September	224	13,983	62	133	9,875	74
18th September	226	12,746	56	102	7,709	76
25th September	182	7,721	42	186	12,810	71
30th September	100	5,012	50	69	13,923	202

TABLE II.- DIFFERENCE IN RANGE OF TIDE. ABERDEEN, 1862-1913.

(From data given by Professor D'Arcy W. Thompson, C.B., "On Mean Sea Level and its Fluctuations.")

Year.	Range.	Month.	Range.	Month.	Difference.	Range.	Month	Range.	Month.	Difference.	Sum of Differences
1862	9·29	3	9·00	6	0·29	9·57	9	8·84	12	0·73	1·02
1863	9·30	2	9·22	6	0·08	9·77	8	8·81	12	0·96	1·04
1864	9·51	4	9·39	5	0·12	9·49	8	8·97	11	0·52	0·64
1865	9·49	4	9·17	5	0·32	9·50	9	8·80	12	0·70	1·02
1866	9·36	3	9·28	6	0·08	9·62	9	8·80	12	0·82	0·90
1867	9 53	2	9·35	6	0·18	9·70	8	8·74	12	0·96	1·14
1868	9·59	4	9·15	6	0·44	9·59	10	8·95	12	0·64	1·08
1869	9·76	3	9·05	7	0·71	9·36	9	9·03	12	0·33	1·04
1870	9·52	2	9·09	6	0·43	9·55	8	8·17	12	1·38	1·81
1871	9·20	4	9·17	5	0·03	9·44	8	8·59	12	0·85	0·88
1872	9·19	4	9·01	7	0·18	9·24	9	8·73	12	0·51	0·69
1873	9·52	3	8·54	7	0·98	9·31	9	8·51	12	0·80	1·78
1874	9·29	4	8·83	6	0·46	9·40	9	7·91	12	1·49	1·95
1875	9·00	4	8·77	6	0·23	9·24	9	8·72	11	0·52	0·75
1876	9·01	2	8·63	7	0·38	9·11	9	8·50	12	0·61	0·99
1877	9·51	3	8·63	6	0·88	9·23	9	8·61	12	0·62	1·50
1878	9·26	3	8·74	6	0·52	9·75	8	8·57	1	1·18	1·70
1879	9·35	2	8·97	6	0·38	9·46	9	8·81	12	0·65	1·03
1880	9·51	3	8·96	7	0·55	9·34	9	9·11	11	0·23	0·78
1881	9·62	3	8·13	6	1·49	9·44	9	8·95	12	0·49	1·98
1882	9·37	4	9·21	5	0·16	10·16	8	8·81	12	1·35	1·51
1883	9·46	4	9·41	5	0·05	9·72	9	9·22	12	0·50	0·55
1884	9·86	3	9·31	8	0·55	9·59	10	9·50	12	0·09	0·64
1885	9·90	3	9·30	6	0·60	9·68	9	9·26	1	0·42	1·02
1886	9·48	4	9·37	6	0·11	9·97	8	9·09	1	0·88	0·99
1887	9·55	2	9·16	5	0·39	9·73	10	9·19	12	0·54	0·93

TABLE II.—(Continued).

Year.	Range.	Month.	Range.	Month.	Difference.	Range.	Month.	Range.	Month.	Difference.	Sum of Differences
1888	9·81	3	9·09	7	0·72	9·39	9	9·27	11	0·12	0·84
1889	10·03	4	9·14	6	0·89	9·57	9	8·94	1	0·63	1·52
1890	9·33	2	9·10	6	0·23	9·95	9	8·76	12	1·19	1·42
1891	9·27	3	8·87	7	0·40	9·19	10	8·70	12	0·49	0·89
1892	9·50	3	8·74	6	0·76	9·07	9	8·81	1	0·26	1·02
1893	9·29	3	8·56	6	0·73	9·25	9	8·57	12	0·68	1·41
1894	9·09	2	8·68	6	0·41	9·34	9	8·61	12	0·73	1·14
1895	9·07	3	8·80	5	0·27	9·08	9	8·71	12	0·37	0·64
1896	9·51	3	8·69	7	0·82	8·94	11	8·86	12	0·08	0·90
1897	9 28	3	8·67	6	0·61	9·49	9	8·79	12	0·70	1·31
1898	9·07	2	8·67	3	0·40	9·47	9	8·87	12	0·60	1·00
1899	9·36	3	9·10	7	0·26	9·31	9	8·83	12	0·48	0·74
1900	9 76	3	8·92	6	0·84	9·41	9	9·01	12	0·40	1·24
1901	9·47	2	9·12	5	0·35	9·62	9	9·18	12	0·44	0·79
1902	9·42	2	9·01	5	0·41	9·57	9	8·99	12	0·58	0·99
1903	10·07	1	9·22	2	0·85	9·54	6	9·07	10	0·47	1·32
1904	9·75	3	9·32	7	0·43	9·46	9	9·04	1	0·42	0·85
1905	9·70	3	9·20	7	0·50	9·73	10	9·18	12	0·55	1·05
1906	9·41	3	9·12	6	0·29	9·47	9	8·99	12	0·48	0·77
1907	9·42	4	9·18	6	0·24	9·29	7	8·69	2	0·60	0·84
1908	9·33	3	8·87	7	0·46	9·17	9	8·79	1	0·38	0·84
1909	9·23	2	8·24	8	0·99	8·96	11	8·56	1	0·40	1·39
1910	8·88	3	8·76	5	0·12	9·14	9	8·54	12	0·60	0·72
1911	9·21	3	8·82	6	0·39	8·93	7	8·52	10	0·41	0·80
1912	9·16	4	8·56	6	0·60	9·11	9	8·61	1	0·50	1·10
1913	8·96	2	8·48	3	0·48	9·27	10	8·54	12	0·73	1·21

TABLE III.

HERRINGS CURED (Barrels 1,000).—SCOTLAND, EAST COAST

(including Orkney and Shetland).

Year.	1	2	3	4	5	6	7	8	9
1815	74	117	127	244	295	342	242	199	305
1824	257	321	233	326	290	252	367	295	315
1833	372	270	413	301	390	428	448	413	521
1842	495	491	378	427	480	459	493	580	450
1851	459	420	647	543	642	489	450	522	364
1860	527	545	626	521	467	448	471	574	427
1869	457	607	679	686	807	867	842	513	684
1878	773	627	1201	904	978	1048	1456	1319	1142
1887	1090	873	1184	1123	859	1095	1288	1412	1394
1896	1334	805	1593	984	1067	1452	1633	1471	1908
1905	1931	1846	2371	1971	1689	2146	1875	1839	1580
1914	1362	90	471	289	295	1076	864	Bad	(?)
1824 to 1913	8695	6735	9325	7786	7669	8684	9323	8938	8783

SCOTLAND, WEST COAST.

1815	76	64	81	82	77	91	58	34	54
1824	65	43	43	48	48	60	47	52	78
1833	65	46	47	57	71	68	55	91	81
1842	63	86	82	68	79	56	59	102	79
1851	105	59	107	79	110	102	100	83	93
1860	110	106	172	88	143	153	174	230	211
1869	218	226	146	88	132	134	101	85	164
1878	132	215	272	207	305	222	241	254	170
1887	214	246	214	181	267	163	122	106	134
1896	158	185	212	191	189	154	170	148	155
1905	181	152	207	229	202	183	172	183	307
1914	252	85	163	188	92	123	153	—	—
1824 to 1913	1311	1364	1502	1236	1546	1295	1241	1334	1472

TABLE III.—(Continued).

HERRING CATCHES (Lasts of 10 crans).—GREAT YARMOUTH.

Year.	1	2	3	4	5	6	7	8	9
1869	13,608	19,420	19,008	14,451	18,796	17,724	11,820	12,824	18,898
1878	10,154	11,677	14,004	16,725	17,166	19,674	24,639	15,793	21,026
1887	18,346	18,852	23,314	14,278	12,905	16,740	15,117	17,407	16,470
1896	18,975	22,501	18,392	26,450	28,483	28,690	44,065	39,333	40,560
1905	38,324	34,535	51,701	44,546	48,292	38,164	53,333	68,357	82,421
1914	17,746	12,012	1,229	7,782	20,249	45,357	61,681	35,857	—
1869 to 1913	99,407	106,985	126,419	116,450	125,642	120,992	148,974	153,714	179,375

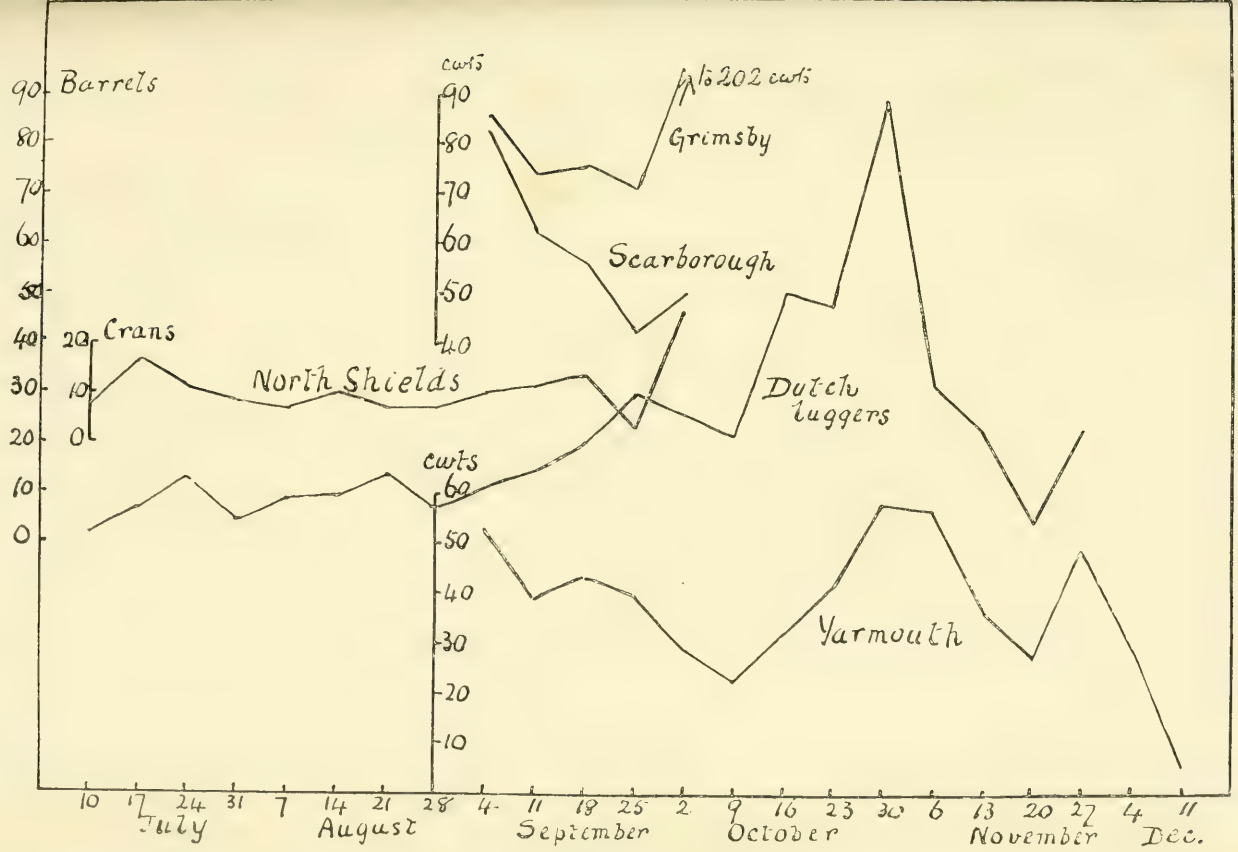


FIGURE I.

Herring Catches, 1920.

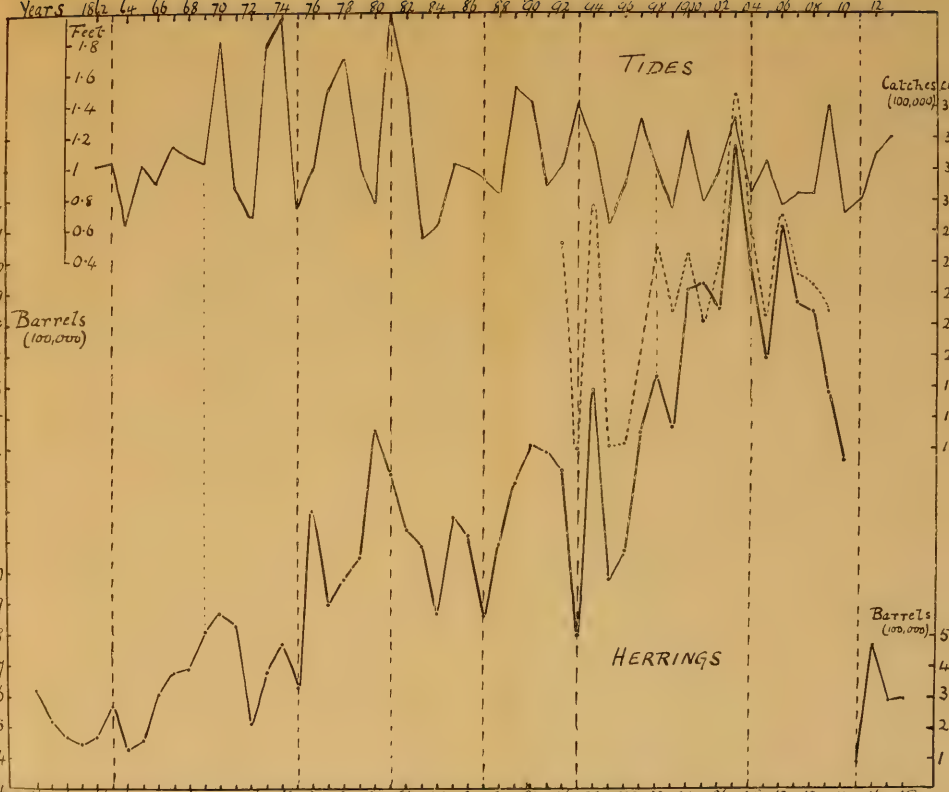


FIGURE II.

Herrings cured, East Coast Scotland, and Tidal Data for Aberdeen.

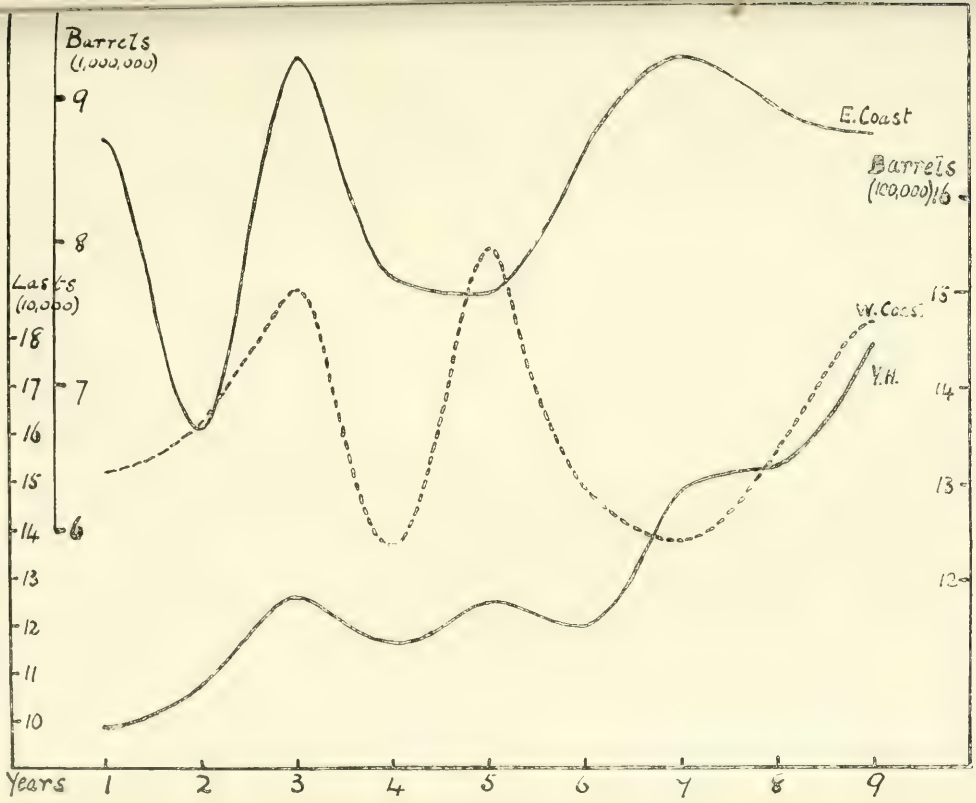


FIGURE III.

Herrings cured, East and West Coast of Scotland, 1824 to 1913.
Herring catches, Great Yarmouth, 1869 to 1913

(Nine-year periods; *see* Table III.)

SALINITY OF INSHORE WATERS.

By E. M. MEEK.

Owing to the very meagre information available as regards the salinity of inshore waters, it was decided to take fortnightly samples at Cullercoats throughout the year 1922.

The locality of the station was as follows:—Cullercoats, beacons on; Tyne Lights, South Pier just clear of North Pier, and, with one exception, when the sea was too rough, the boat went exactly to this spot on every occasion. Unfortunately, however, owing to very stormy weather during the second fortnight in January, when none of the fishing boats ventured out at all, no sample was obtained for that period.

The results (Table I) until the 16th of March show nothing of much moment, but the considerable drop in salinity on that date, and again on March 31st, had to be explained. It was noted that whereas the previous samples had been taken at or very near high tide, the two in question were taken several hours before that time.

With this in mind, it was decided to take samples at the same spot every two hours during a complete neap tide and a spring tide. The dates fixed were April 6th and 13th, and the results are shown in Table II, and graphically in Figs. 1 and 2.

The ebb tide off Cullercoats runs in a northerly direction and turns seawards, whereas the flood tide is a southerly current which ends by turning towards the land. It is evident therefore that normally the ebb tide will have the effect of directing the outflow from the River Tyne towards Cullercoats, which is only one mile to the north of the river, and that a series of observations during a complete tide should prove this.

Figure 1 shows that this is the case. The results, however, are apt to be disturbed by the winds. Those from the south and east accentuate the effect of the Tyne water on the salinity at Cullercoats, while those from the north and west tend to neutralise that effect. (Table II., Fig 2).

TABLE I.

Date.	Time.	Depth.	Tide. High Water at Shields.	Wind.	Weather.	State of Sea.	Temperature.	Sp. Gr. at 17·5 C.	Chlorine. Parts per 1000.	Salinity per 1000.	Remarks.
	Summer.	Faths.	Summer.								
9/1/22	11·20 a.m....	6	11·24 a.m....	W.S.W	Moderate	Smooth ...	44 F. ...	1·02619	18·98	34·29	High tide.
8/2/22 ...	11·40 a.m....	6	11·48 a.m....	S.W. ...	Moderate	Smooth ...	4° C. ...	1·02616	18·96	34·25	High tide.
23/2/22	11·30 a.m....	6	1·32 p.m. ...	W. ...	Fine, but overcast ...	Slightly choppy	5·5° C. ...	1·02625	19·025	34·37	Half flood.
16/3/22	11·20 a.m....	6	5·25 p.m. ...	N.E. ...	Fine	Smooth ...	6° C. ...	1·02595	18·805	33·97	End of ebb.
31/3/22	2·40 p.m. ...	3	6·2 p.m. ...	E.N.E. ...	Stormy	Rough	5 C. ...	1·02591	18·78	33·93	Beginning of flood. Only part of distance accomplished owing to heavy sea.
6/4/22 ...	10·30 a.m....	6	10·33 a.m....	N.E. ...	Fine	Slight swell ...	5° C. ...	1·02614	18·945	34·225	High tide.
13/4/22	5·30 p.m. ...	6	5·17 p.m. ...	N.W. ...	Bright, but cold ...	Heavy swell ...	6° C. ...	1·02615	18·95	34·23	High tide.
6/5/22 ...	10·45 a.m....	6	11·37 a.m....	S.W. ...	Fine	Smooth ...	8° C. ...	1·02616	18·96	34·25	End of flood.
22/5/22	1 p.m. ...	6	1·11 p.m. ...	S.W. ...	Changeable	Smooth ...	9·5° C. ...	1·02609	18·91	34·16	High tide.
5/6/22 ...	12 noon ...	6	12·19 p.m.	S.W. ...	Fine	Smooth ...	10° C. ...	1·02609	18·91	34·16	High tide.
1/7/22 ...	8.30 a.m. ...	6	8·53 a.m.	S.W. ...	Unsettled ; showery ...	Smooth ...	55° F. ...	1·02623	19·01	34·34	High tide.

Figure 1.

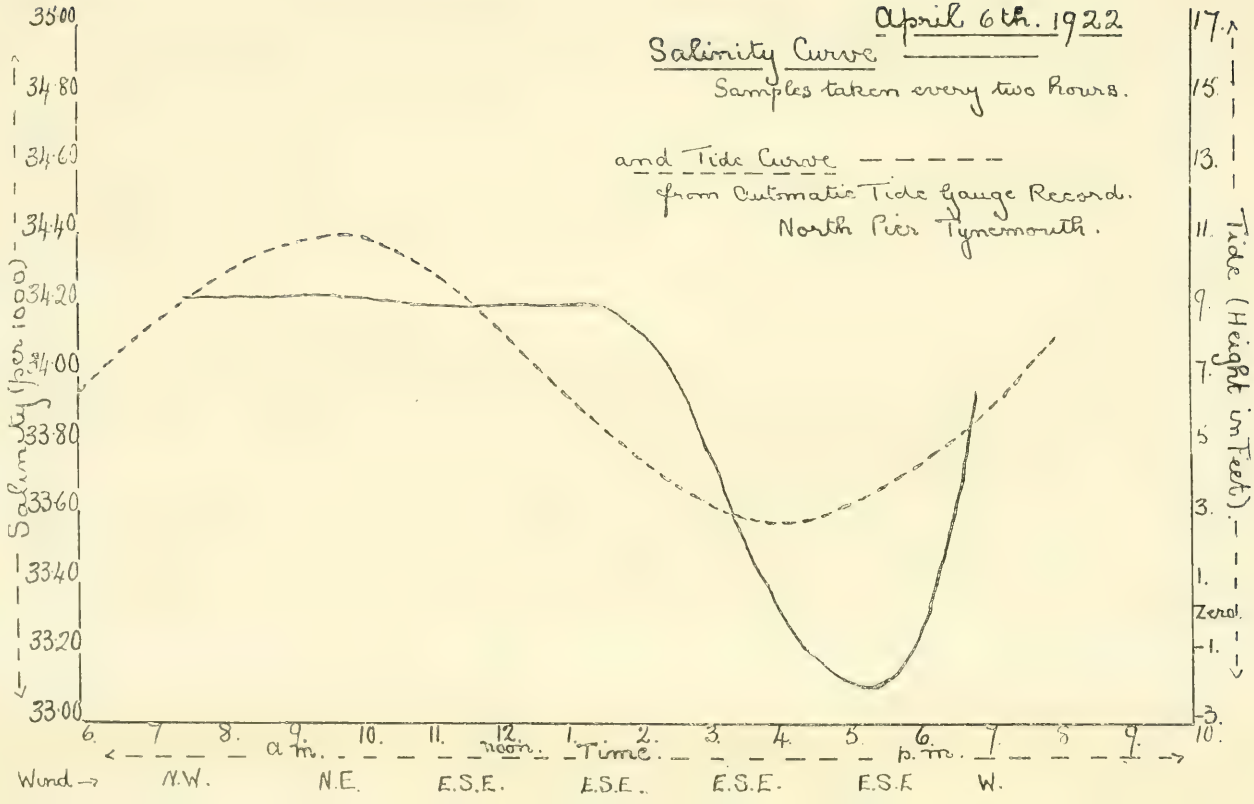

April 6th. 1922
Salinity Curve
Samples taken every two hours.
and Tide Curve
from Automatic Tide Gauge Record.
North Pier Tynemouth.
Salinity (per 1000)
Tide (Height in Feet)
35·00
34·80
34·60
34·40
34·20
34·00
33·80
33·60
33·40
33·20
33·00
17.
15.
13.
11.
9.
7.
5
3.
1.
Zero.
-1.
-3.
6. 7. 8. 9. 10. 11. 12. noon. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.
a m. Time. p. m.
Wind → N.W. N.E. E.S.E. E.S.E. E.S.E. E.S.E W.

Figure 2.

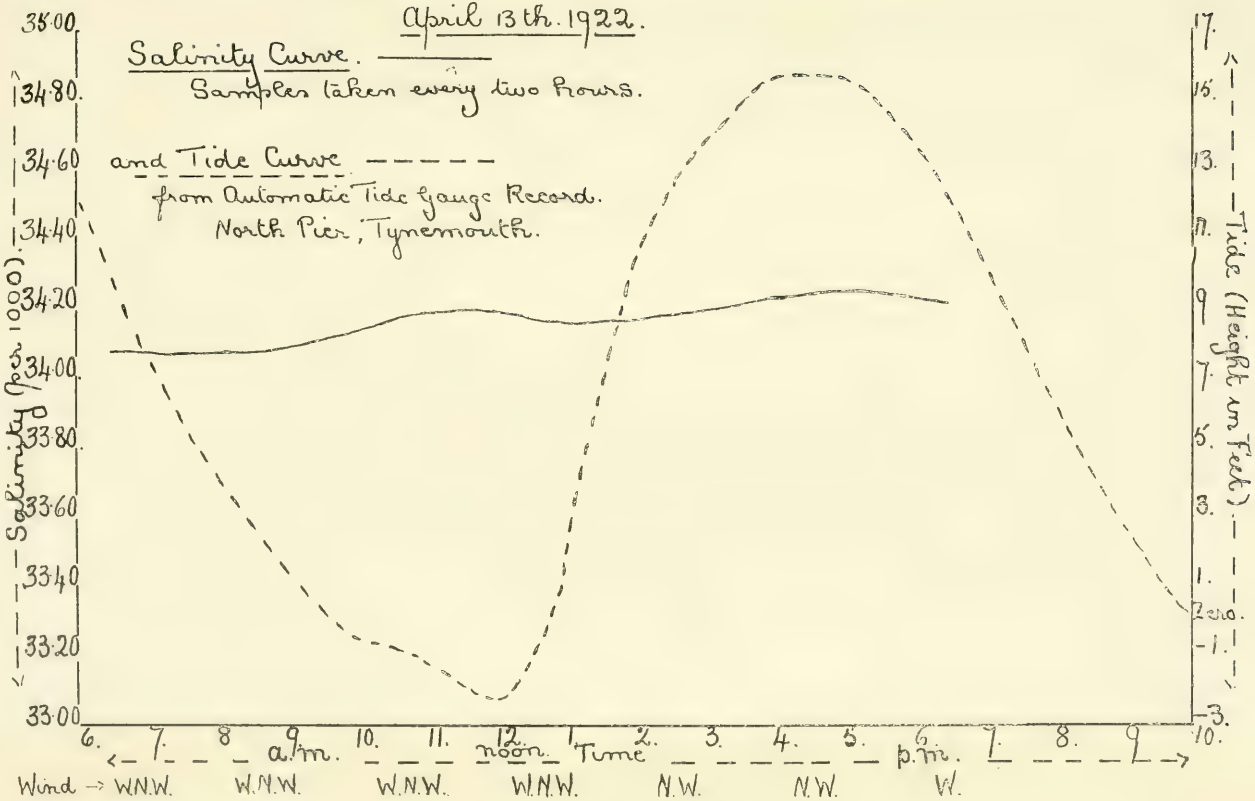

April 13th. 1922.
Salinity Curve.
Samples taken every two hours.
and Tide Curve
from Automatic Tide Gauge Record.
North Pier, Tynemouth.
Salinity (per 1000).
Tide (Height in Feet).
35·00
34·80
34·60
34·40
34·20
34·00
33·80
33·60
33·40
33·20
33·00
17.
16.
13.
11.
9.
7.
5.
3.
1.
-1.
-3.
6. 7. 8. 9. a.m. 10. 11. 12 noon 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.
Time
Wind → W.N.W. W.N.W. W.N.W. W.N.W. N.W. N.W. W.

TABLE II.

Date.	Time.	Tide at North Pier, Tynemouth.		Depth.	Temperature.		Wind.	State of Sea.	Weather.	Sp. Gr. at 17·5° C.	Chlorine. Parts per 1000.	Salinity per 1000.
		Greenwich Time.	Height.		Air.	Sea.						
	Summer		Feet.	(Fathoms).								
6/4/22 ...	8·30 a.m. ...	6 a.m. ...	6·5	6	3° C.	5° C.	N.W. ...	Slight swell ...	Fine	1·02613	18·94	34·22
		8 a.m. ...	9·75									
	10·30 a.m....	10 a.m. ...	11	6	4° C.	5° C.	N.E. ...	,, ...	,, ...	1·02614	18·945	34·225
	12·30 p.m.	12 noon ...	8·5	6	6° C.	6° C.	E.S.E. ...	,, ...	,, ...	1·02612	18·93	34·2
	2·30 p.m.	2 p.m. ...	4·75	6	6° C.	6° C.	E.S.E. ...	,, ...	,, ...	1·02612	18·93	34·2
	4·30 p.m. ...	3·30 p.m. ...	3	6	6° C.	6° C.	E.S.E. ...	,, ...	,, ...	1·02564	18·58	33·57
		4 p.m. ...	2·8									
	6.30 p.m ...	6 p.m. ...	4·25	6	5° C.	5·5 C.	E.S.E. ...	,, ...	,, ...	1·02528	18·32	33·1
	7·55 p.m. ...	8 p.m. ...	8	6	5° C.	5·5 C.	W. ...	Swell	,, ...	1·02593	18·79	33·95
		10 p.m. ...	10·1									
13/4/22	7·30 a.m. ...	6 a.m. ...	12·1	6	5 C.	6 C.	W.N.W.	Smooth ...	Bright, but cold ...	1·02602	18·86	34·07
		8 a.m. ...	4·1									
	9·30 a.m. ...	10 a.m. ...	—0·5	6	6° C.	6° C.	W.N.W.	,, ...	,, ,, ...	1·02602	18·86	34·07
		10·30 a.m....	—0·65									
	11·30 a.m....	12 noon ...	—2·25	6	8° C.	6° C.	W.N.W.	Swell	,, ,, ...	1·02609	18·91	34·16
	1·30 p.m. ...	2 p.m. ...	10·25	6	8° C.	6° C.	W.N.W.	,, ...	,, ,, ...	1·02609	18·91	34·16
	3·30 p.m. ...	4 p.m. ...	15·5	6	8° C.	6° C.	N W. ...	Heavy swell ...	,, ,, ...	1·02610	18·915	34·17
		4·30 p.m. ...	15·65									
	5·30 p.m. ...	6 p.m. ...	13·75	6	8° C.	6° C.	N.W. ...	,, ...	,, ,, ...	1·02615	18·95	34·23
		8 p.m. ...	6·2									
	7·30 p.m. ...	10 p.m. ...	Zero	6	8° C.	6° C.	W. ...	,, ...	,, ,, ...	1·02612	18·93	34·20

TYNE POLLUTION.

By E. M. MEEK.

In February of this year an "Experimental Sub-Committee for Watershed of River Tyne" was formed in connexion with the Ministry of Agriculture and Fisheries Standing Committee on Rivers Pollution.

The members of this Sub-committee are as follows :—

1.—Dr. A. Meek, Chairman.
2.—E. G. Barnett, representing Federation of British Industries.
3.—Alderman Wm. Clough, J.P., representing Tyne Port Sanitary Authority.
4.—Dr. W. N. Haworth, Professor of Chemistry.
5.—Dr. E. C. Jee, Inspector of Fisheries.
6.—H. Paynter, Inspector of Fisheries.
7.—F. G. Tuck, representing Tyne Salmon Conservancy.
8.—E. M. Meek, Secretary.

Three meetings have already been held, and the motor yacht "Evadne" has three times made cruises up the Tyne for the purpose of taking samples of water from all parts of the river. The Tyne Improvement Commission has also kindly granted permission for experimental work to be carried on at the Swing Bridge, Newcastle—a badly polluted area—where samples can be taken and immediately analysed on the spot.

This work has proved quite conclusively that the Tyne is frequently insufficiently oxygenated over large areas.

The Sub-committee has had the good fortune, however, to begin its experimental work during a good year so far as the descending smolts were concerned, so the results of the analysis of the water samples will form an interesting basis for comparison in future years.

At the first meeting of the Sub-committee, held at Armstrong College on Tuesday, February 21st, the causes of smolt mortality were discussed.

(A) Drought.—Absence of a suitable freshet at the right time.
(B) Sewage.—No attempt being made on Tyneside to treat or even screen the sewage.
(C) Trade Effluents.—Especially those containing tar products and free mineral acids.

It was generally felt that no practical measures could be recommended which would be likely to counteract the influence

of drought. The production of an artificial spate would be too costly a matter. The netting of smolts and their transfer to salt water was proposed, but for the present was not recommended owing to the difficulties and cost involved. In this connexion, however, experiments were carried out at Cullercoats to discover the effect of transferring smolts direct from fresh water to salt water.

Inspector Crawford, of the Tyne Salmon Conservancy, kindly brought some smolts to the Dove Marine Laboratory, where they were placed in fresh water overnight to recuperate from the journey.

Next day tanks were arranged containing :—

(1) One-quarter sea water, three-quarters fresh water.
(2) One-half sea water, one-half fresh water.
(3) Three-quarters sea water, one-quarter fresh water.
(4) Sea water undiluted (Salinity 34.25).

The smolts were transferred direct from the fresh water to the above tanks with practically no handling, and all stood the transfer to salt water with perfect equanimity.

Some time later another batch of smolts was brought to Cullercoats. The weather was very warm at the time, and the fish had been handled while they were being caught, so arrived in an exhausted condition. In order to make the test as severe as possible they were immediately transferred to a tank containing sea water, but this proved too much for them, and it is hoped to repeat the experiment next spring with larger numbers of smolts and under more variable conditions.

As the first two proposals were impracticable in the meantime, it was agreed that the most practicable measure was to abate the degree of pollution in the tideway at the time when the smolts were descending to the sea. The Sub-committee therefore recommended that Mr Tuck should draft a suitable letter to be sent out by the Tyne Salmon Conservancy to all firms discharging noxious effluents, inviting them to hold up all such discharges until 2-3 hours following high tide, during the descent of the smolts. The firms in question sent very satisfactory replies to this letter, and offered to do all in their power to assist the Sub-committee.

The trout smolts this season began to migrate in the second week of April. There was a fair amount of water in the river at this time, and the weather was cold, so they were able to pass

through the polluted area with very little mortality, and it was not till May 11th that a sudden short spell of very hot weather caused the death of a number of smolts above the Redheugh Bridge, at the Gateshead side of the river.

As soon as this information was received, Mr. Tuck telephoned to the Team By-Product Co. and the Gateshead Gas Works asking them to hold up their effluents till 2-3 hours after high tide, so that they would be carried immediately down the river. At great expense and trouble to themselves these two firms complied with the request, and undoubtedly did a considerable amount of good, for which the Sub-committee is extremely grateful.

On Friday, May 12th, twelve of the dead smolts (all trout) found on the shore beside Gateshead Gas Works were sent to Cullercoats for examination. In every case the gills, &c., were found to be impregnated with tar.

On May 15th a large number of brown trout were found in the Derwent below the paper mill. No deaths had been notified above the paper mill, but as the fish had been stored for over a week before being submitted for examination, the cause of death was not definitely ascertained.

The salmon smolts began to migrate about May 16th under rather less favourable conditions than the trout smolts had experienced at the beginning of their descent.

On May 26th further samples (the majority, salmon) were sent to Cullercoats. These had again been found near Gateshead Gas Works, and were covered with tar.

On May 30th information was received that the smolts had finished running, and Mr. Tuck telephoned next day to the two firms releasing them from their promise to hold up their effluents till the ebb tide. Unfortunately the information was somewhat premature, and hundreds of salmon smolts were found dying on June 7th, but it was decided that nothing further could be done in the matter this season.

Appended will be found tables and graphs showing the salinity of the Tyne at different points visited by the " Evadne " when cruising in the river for the purpose of taking water samples.

The details of the analyses of these samples have been withheld in the meantime, and will be published later in the special report to be submitted by the Sub-committee.

Figure 3.

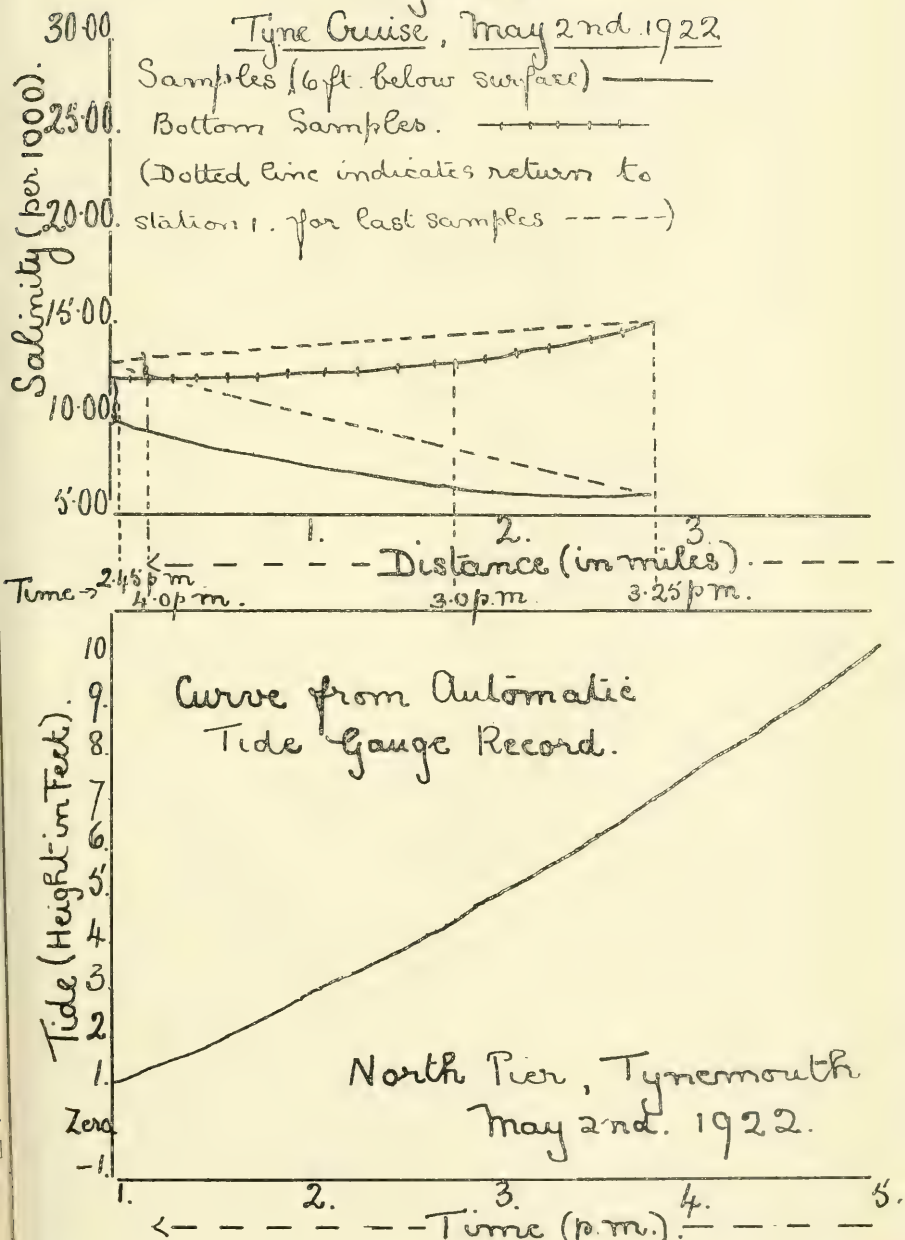

Tyne Cruise, May 2nd 1922
Samples (6 ft. below surface)
Bottom Samples.
(Dotted line indicates return to station 1. for last samples)
Salinity (per 1000).
30·00
25·00
20·00
15·00
10·00
5·00
1.
2.
3
Distance (in miles)
Time → 2.45 p.m.
4·0 p.m.
3·0 p.m.
3·25 p.m.
Curve from Automatic Tide Gauge Record.
Tide (Height in Feet).
10
9
8
7
6
5
4
3
2
1.
Zero
-1
North Pier, Tynemouth
May 2nd. 1922.
1.
2.
3.
4.
5.
Time (p.m.)

Figure 4.

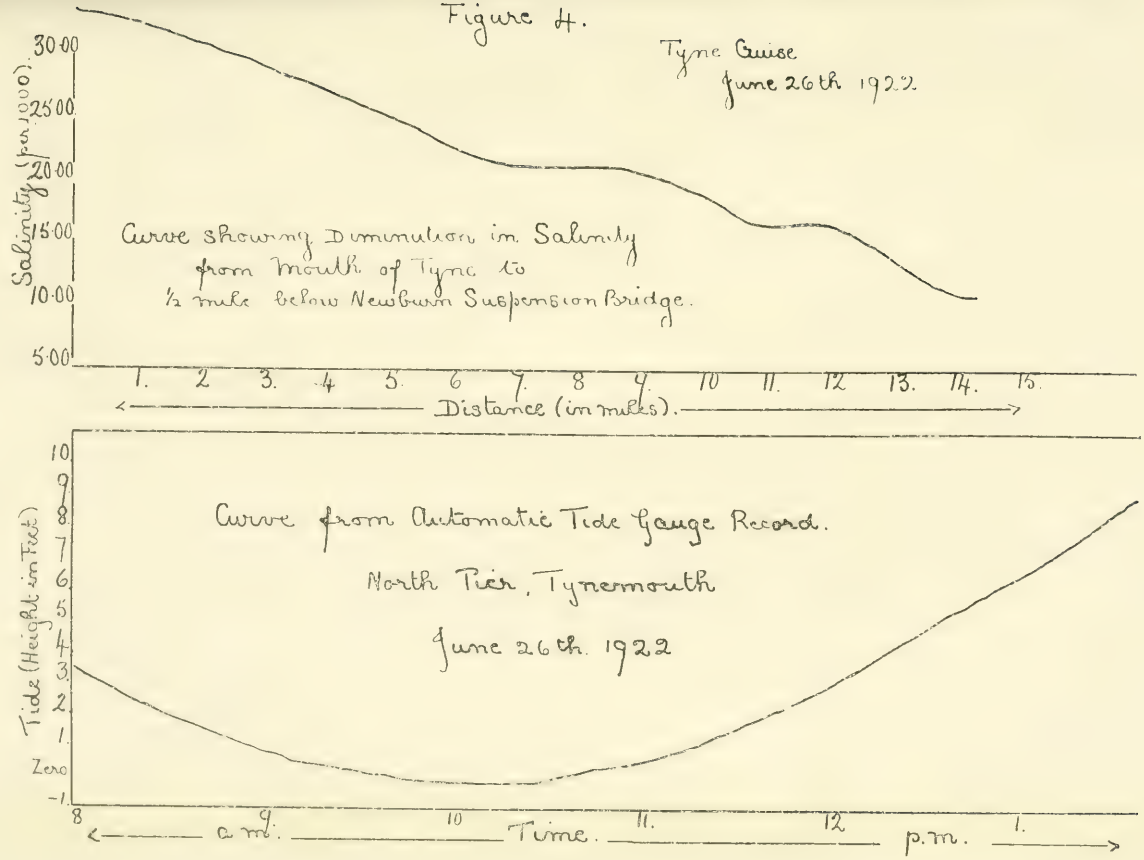

Tyne Cruise
June 26th 1922.
Salinity (parts per 1000).
30·00
25·00
20·00
15·00
10·00
5·00
Curve showing Diminution in Salinity
from Mouth of Tyne to
½ mile below Newburn Suspension Bridge.
1. 2 3. 4 5. 6 7. 8 9. 10 11. 12 13. 14. 15.
Distance (in miles).
Curve from Automatic Tide Gauge Record.
North Pier, Tynemouth
June 26th. 1922
Tide (Height in Feet)
10
9
8
7
6
5
4
3
2
1
Zero
-1
8
a.m.
9.
10
Time.
11.
12
p.m.
1.

TABLE III.—MAY 2ND, 1922.

Station.	Locality.	Time.	Salinity.	Height of Tide at North Pier.	
				Time.	Height.
H.—6 ft.	Mouth of Ouseburn (south bank of river)	2·45 p.m.	10·32	1·0 p.m.	1 ft.
18 ft.		—	12·43		
J.—6 ft.	Tyneside Brass and Iron Foundry	3·0 p.m	6·73	3·0 p.m.	5 ft.
20 ft.			13·42		
K.—6 ft.	Cochran-Carr's Firebrick Works	3·25 p.m.	5·99		
18 ft.			15·16		
L.—6 ft.	Opposite Ouseburn (return journey)	4·0 p.m.	13·06	5·0 p.m.	10·25 ft.
14 ft.	(North bank)		13·5		

TABLE IV.—JUNE 26TH, 1922.

Station.	Locality.	Time.	Salinity.	Height of Tide at North Pier.	
				Time.	Height.
A.—6 ft.	At sea, approaching Pier head ...	9·5 a.m.	33.96	9·0 a.m.	1·0 ft.
30 ft.			33·96		
B.—6 ft.	Shields Engineering and Dry Dock Co.	9·40 a.m.	31·06	9·50 a.m.	Zero
12-15 ft.			31·56		
C.—6 ft. ...	Jarrow Slake	10·5 a.m.	28·53	10·0 a.m.	— ·05 ft.
18 ft.			29·88	10·30 a.m.	— ·05 ft.
D.—6 ft.	Near Walker Pier	10·40 a.m.	22·61	10·45 a.m.	0·25 ft.
E.—6 ft.	Hawthorn, Leslie & Co , ...	11·20 a.m.	21·18	11·0 a.m.	0·5 ft.
Bottom			21·38		
F.—6 ft.	Ouseburn	11·30 a.m.	20·95		
Bottom			21·0		
G.—6 ft.	Redheugh Bridge	11·55 a.m.	18·60		
Bottom			20·52		
H.—6 ft.	Mouth of River Team	12·5 p.m.	16·69	12·0 a.m	3·0 ft.
Bottom			22·56		
K.—6 ft.	Mouth of River Derwent	12·30 p.m.	16·31		
Bottom			12·86	1·0 p.m.	6·5 ft.
L.—6 ft.		12·45 p.m.	11·82		
M.—6 ft.	½ mile below Newburn Suspension Bridge	1·0 p.m.	11·00	2·0 p.m	10·25 ft.

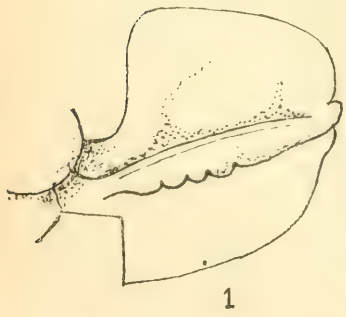
A NEW VARIETY OF *PLEUROCRYTA GALATHEAE* FROM THE NORTHUMBERLAND COAST.

By F. W. FLATTELY, M.Sc.

In August of last year (1921) when shore collecting close to St Mary's Island (Northumberland) I secured a specimen of *Galathea squamifera*, which proved to be parasitised by an adult female *Pleurocrypta*, carrying a male attached to the underside of the abdomen.

Since the specimen appears to coincide completely neither with *Pleurocrypta galatheae* as described by Bonnier nor with the *P. longibranchiata* of Sars, and since also properly authenticated records of these parasites are distinctly rare from British coasts, a short record of its chief characteristics would appear to be useful.

A striking feature of the female is its perfect bilateral symmetry. This, though not a diagnostic character—the degree of asymmetry in Bopyrids being usually subject to variation according to the particular position occupied by the parasite in the gill chamber—is of considerable interest physiologically since the present specimen



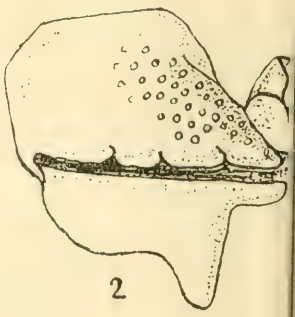


FIGURE I.

PLEUROCRYPTA GALATHEAE.

1.—Inner aspect of first right oostegite. 2.—Outer aspect of same.

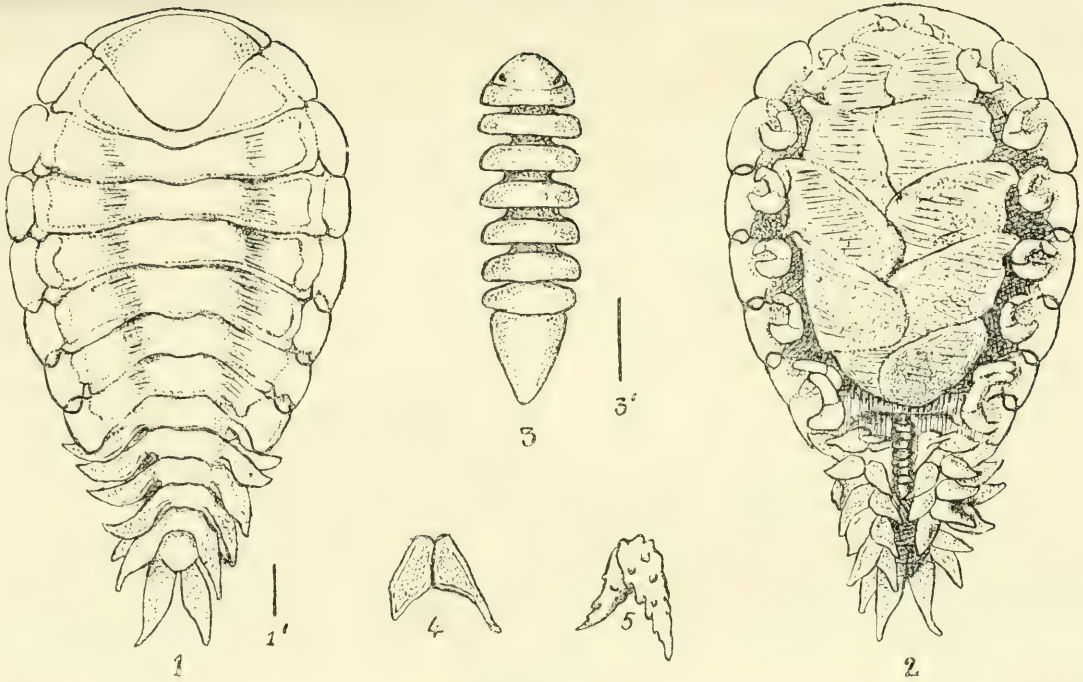


PLATE I.

PLEUROCRYPTA GALATHEAE var. NORTHUMBRIENSIS.

1' equals one mm. under same magnification.

1.—Dorsal surface of female.

2.—Ventral surface of female.

3.—Dorsal surface of male.

4.—Pleopods of female specimen here described.

3' equals half mm. under same magnification

5.—Pleopods of specimen figured by Bonnier.

was fully grown and had exerted sufficient pressure upon the left gill-cover of the host to cause it to become conspicuously deformed. Of greater importance for the determination of the species is the character of the pleopods, which are flat, leaf-like and perfectly smooth (Pl. I., Fig. 4) in contrast to those figured by Bonnier for *P. galatheae*, which are markedly tuberculate and appear to be cylindrical rather than lamellar (Pl. I., Fig. 5) The first pair of incubatory plates differ from those of Bonnier's specimen in certain points of detail, the importance of which, however, it is not intended to stress.

British records of *Pleurocrypta galatheae* on *Galathea squamifera* include those of Loughrin from Polperro, of the Rev. A. M. Norman from the Shetlands and of Tattersall from the west coast of Ireland. The form figured by Bate and Westwood as *Phryxus longibranchiatus* from *G. squamifera*, which Sars has described as a distinct species *Pleurocrypta longibranchiata*, is regarded by Bonnier as merely the young form of *P. galatheae*. Bate and Westwood also refer to the Rev. Norman's announcement of this same form *Phryxus longibranchiatus* as occurring upon a specimen of *Pagurus thompsoni* dredged from Tynemouth, 1863, but this is almost certainly an error—as Norman himself later admitted—due to confusion of this form with a species of *Pseudione*, probably *P. hyndmanni*. Dr. W. T. Calman has very kindly compared my specimen with those of *P. galatheae* in the Norman collection, labelled as from Starcross (Devon), from Jersey and merely as "British," and states they all differ from my own in general appearance and in having the pleopods conspicuously more tuberculated.

There is room for confusion in connection with the identification of Epicarid parasites as a result of the difference of opinion among specialists as to whether a particular species is or is not definitely restricted to a single species of host. Giard and Bonnier take the first view, Sars and Hansen the second. Thus, as already noted, Sars ascribes to *Galathea squamifera* a second species of parasite *P. longibranchiata*, in addition to the one (*P. galatheae*) already admitted. Tattersall, who has taken both forms from separate individuals of *G. squamifera*, inclines to agree with Giard and Bonnier that they are really one and the same species. The fact that Sars' *P. longbranchiata* is distinctly smaller than *P. galatheae* also points to its being a young form of the latter. In any case, the authority

of Giard and Bonnier is such as to make one extremely hesitant of establishing new species, and I will therefore content myself with recording provisionally the specimen in my possession as a variety of the type species, viz., *Pleurocrypta galatheae*, var. *northumbriensis*.

A summary of such characters as are generally used for diagnosis is appended.

The female measures from the frontal margin of the cephalon to the extremities of the uropods 13 mm. Colour, yellowish white, unpigmented: form, perfectly symmetrical with pyriform outline, the fact that the pleura of the right side are bent slightly backwards being the only evidence of the pressure exerted by the carapace of the host: thoracic somites uniformly decreasing in width from the third to the first, and from the third to the seventh: lateral cuticular extensions of the thoracic somites (pleura) leaf-like, semi-transparent, longer than the somite itself and overlapping, the posterior portion of each pleuron overlapping the anterior portion of the one immediately following. The margins of the somites immediately proximal to the pleura marked by crescentic or reniform cuticular bosses which are continued as longitudinal ridges along the posterior margin of each segment: pleura developed on the first five segments of the pleon and slightly wider than the segments themselves, somewhat crescentic in shape and semi-transparent. Antennules, antennae and maxillipeds normal, pereiopods completely concealed beneath the pleura. Outer surface of first pair of incubatory plates (Fig. 1) subdivided into an anterior and a posterior portion by a deep groove or hollow fold: the anterior portion with its surface covered with small tubercles and its posterior margin (bordering the fold) somewhat crenate, the posterior portion, which in the natural position is concealed beneath the incubatory plates immediately following, with its surface smooth, and prolonged behind into a blunt tongue-like process. Inner surface of the first pair of incubatory plates similarly subdivided by a prominent transverse crest ("crête interne" of Bonnier), showing a short series of three or four shallow digitations at its proximal end, but not, as in Bonnier's specimen, bordée de petits tubercules arrondis placés sur plusieurs rangs: five pairs of flattened pleopods on either side, triangular in shape with elongated apices (which, in the

case of the two anterior pairs, are used for clasping the male), and smooth, non-tuberculate surfaces: a single pair of elongate, triangular uropods, with sharp apices.

The male measures 2·1 mm. in length, and corresponds closely with Bonnier's description. Head rounded: eyes distinct; the seven thoracic segments all approximately of same size: pleon unsegmented, terminating in a roundish apex. Antennules and antennae three-jointed, terminating in a bunch of short, stiff hairs; pereiopods normal, the terminal claw (dactylopodite) most highly developed on the most anterior appendages and gradually decreasing in importance. Pleon without appendages.

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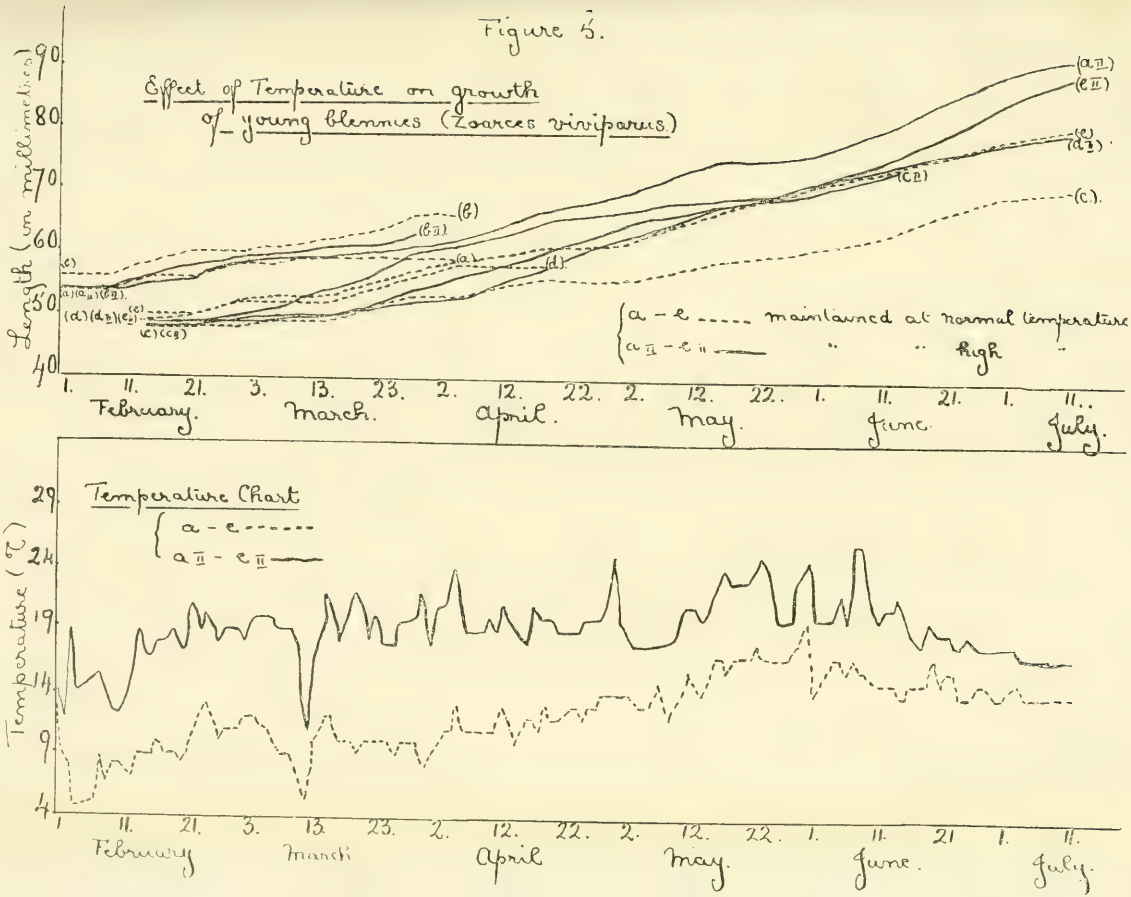
EFFECT OF TEMPERATURE ON GROWTH OF YOUNG BLENNIES (*ZOARCES VIVIPARUS*).

By E. M. MEEK.

Amongst some experiments which are being made on young fish (as to the effects of various conditions on growth) the influence of temperature on young blennies is being observed. In the case of this experiment two tanks were used: one was allowed to remain at the normal temperature and the other consistently maintained at a higher temperature. In each of these, blennies, from the same mother, born in the Laboratory, were placed and measured every week for the first two months of their life, and subsequently every fortnight. Unfortunately some of the blennies died, but it will be seen (in Figure 5), as was expected, that the higher temperature leads to more rapid growth.

Figure 5.


Effect of Temperature on growth of young blennies (Zoarces viviparus.)
Length (in millimetres)
90
80
70
60
50
40
(a II.)
(c II)
(c)
(d II)
(C II)
(B)
(B II)
(C).
(a)
(d).
(c)
(a)(a II)(B II).
(d)(d II)(c)(c II)
(c)(c II)
a - c ..... maintained at normal temperature
a II - c II —— " " high "
1. 11. 21. 3. 13. 23. 2. 12. 22. 2. 12. 22. 1. 11. 21. 1. 11..
February. March. April. May. June. July.
Temperature Chart
a - c .....
a II - c II ——
Temperature (T)
29
24
19
14
9
4
1 11. 21. 3. 13. 23. 2. 12. 22. 2. 12. 22. 1. 11. 21 1. 11.
February March April May. June. July.

A NEW SPECIES OF ENTEROPNEUSTA FROM THE NORTH SEA.

By A. MEEK.

The specimen was captured in a haul made with a Petersen grab during a survey by the Ministry's research vessel, "George Bligh," on August 22nd, 1921, at a depth of 52 fathoms off the Longstone. It thus comes within the Northumberland area, and it was sent to me by Dr. E. S. Russell for identification and description.

It proves to be a new species of the genus Glossobalanus, and has been called *Glossobalanus marginatus*. A full description is given in No. 264 of the "Quarterly Journal of Microscopical Science." Here it may be said that the specimen is the anterior end of a mature male, and that it is peculiar in having been procured from a great depth and in the following structural features :— the large genital wings ; the row of genital pores being not quite marginal, but protected by a thin process of the margin containing a short third branch of each gonad ; the general brown pigmentation concentrated in a paired row of spots along the ventral aspect ; the asymmetry of the branchio-genital region of the body, and of the glandular ridges of the body wall ; and in the asymmetrical disposition of the post-branchial caecum of the alimentary canal.

The occurrence has led to an attempt to associate with the genus Glossobalanus a Tornaria larva previously obtained at St. Andrews, distinguished by its broad anterior region and its simple ciliated bands. A larva of this character has been found in a Plankton gathering made off the Longstone on July 27th, 1921, by the Laboratory's motor boat, "Evadne." It is concluded that a series of isolated communities of the species occurs along the east coast of Britain, the larva being the connecting link between them.

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